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# TEXT OF STATEMENT ON NASA SPACE SCIENCES PROGRAM
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Before the House Committee on Science and Astronautics

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This presentation answers four important questions:

(1) Why must NASA do research in space?

(2) What are the objectives of space sciences research?

(3) What is this agency's space sciences research program?

(4) How much will this space sciences research program cost in fiscal year 1961?

Now, why must NASA do research in space? The many reasons can be summarized by the observation that such research contributes materially to each of the eight objectives enumerated by the Congress in the National Aeronautics and Space Act of 1958 and, in fact, constitutes the very first objective: "The expansion of human knowledge and phenomena in the atmosphere and space". Furthermore, before man ventures into this new and hostile environment of radiation belts, solar winds, cosmic radiation, and meteorites, we must learn enough about this environment to insure man's safety.

Next, what are the NASA space sciences research objectives? In the past, man was limited to observations which could be made at or near the surface of the earth. Now the scientist can send his measuring equipment on sounding rockets and satellites throughout the earth's atmosphere, and into space beyond the moon on lunar and planetary probes. Even those regions of the universe which instruments cannot reach have been opened up to more penetrating study; for telescopes and satellites coursing above the earth's atmosphere can observe the radiations in all of the wave lengths which arrive from the vast depths of space. Unobscured and undistorted by the earth's atmosphere, these radiations may be expected to reveal a hitherto inaccessible wealth of information about the universe.

Seizing upon the new opportunities, scientists the world over are busily investigating a wide range of phenomena. The geophysicist is using sounding rockets and earth satellites to study the properties and behavior of the earth's atmosphere, ionosphere, magnetic field, auroras, and other phenomena in space close to the earth. Cosmic rays, radiation belts, and the solar wind are under intensive investigation thousands of miles above the earth. The moon, the sun, and the stars receive their due share of attention. Cosmic experiments to study gravity and relativity theory, to observe physical processes and materials in the environment of space, and to probe the mysteries of life in space are in preparation. Manned flight away from the earth into the hostile environment of space is imminent. In support of this world-wide quest for knowledge and experience, hundreds of sounding rockets and more than a dozen satellites and space probes are to be fired each year for the foreseeable future.

At first glance, this broad range of activities may seem disconnected and random. But in all this activity there is one simple, coherent pattern. One clear-cut, concise set of objectives ties together and motivates all of this activity. These objectives are:

(1) To understand the nature of the control exerted by the sun over events on the earth;

(2) To learn the nature and origin of the universe, including the solar system; and

(3) To search for the origin of life and its presence outside the earth.

Let us consider the first objective. The sun affects every aspect of human activity. If its radiation were to increase or decrease by a small fraction of one percent, our present mode of existence would undergo marked changes. Knowledge of the sun and its influence on the earth has direct bearing on our daily activity and on our very existence.

Actually, we know that the total solar energy output does not, and should not be expected to, change appreciably. It is for this reason that the solar energy reaching the earth's surface per square centimeter per minute is called the solar constant. It is this energy in the visible and infrared regions of the spectrum which furnishes the driving power for our winds, storms, and the other manifestations of weather.

But one small part of the sun's energy does undergo important fluctuations. This part comprises the gusts of x-rays, ultraviolet light, and charged particles which are emitted from the sun at times of unusual surface turbulence. The radiations travel at the speed of light, reaching the earth some eight minutes after leaving the sun. They are absorbed in the higher levels of the atmosphere, well above our "weather sphere", and produce heating, chemical reactions, and electrical charging of the very thin air. It may be said that they give rise to a sort of upper atmospheric weather whose storms produce heating, chemical reactions, and radio blackouts. The charged solar particles travel at the more modest speed of some 1,000 miles per second, reaching the earth in one or two days. Upon arrival, they are seized by the earth's magnetic field and funneled into the polar latitudes, producing magnetic field storms, modifying the radiation belts, augmenting the auroral displays, and producing longer-lived radio and telephonic communications breakdowns.

One of the most exciting chapters in the history of sun-earth relationships concerns the discovery by James Van Allen of the radiation belts which bear his name. These belts consist of charged particles which are trapped and guided by magnetic lines of force many thousands of miles above the earth's surface. Although the possible radiological effects of these particles are well known, their geophysical role in transferring energy from the sun to the earth, accompanied by heating, auroras, and communications disturbances, may well prove to be more significant.

Experimental evidence obtained during 1959 shows the importance of the Van Allen belts in sun-earth relationships. Pioneer IV, launched in March after five days of unusually intense solar and auroral activity, detected a belt population some ten times greater than that observed by Pioneer III during a period of solar quiet. In October, Explorer VI radioed back counting rates 5000 times lower than those of Pioneer IV; but several weeks later, after some intervening solar activity, Explorer VI counter showed a return of the particle population nearly to its Pioneer IV level.

These fragmentary measurements have led to strong disagreements between the scientists themselves concerning the interpretation of the results and their geophysical importance. Consequently, it is important to measure the populations of such energetic particles over long periods of time and to many tens of thousands of miles from the earth. One entire satellite to be launched in 1960 will be devoted to the observation of these trapped particles, using more complex detectors which will separate the particles by type and by energy. Particularly important will be the first measurement of the very low energy protons (hydrogen nuclei) having energies of less than 10,000 electron volts, which is only half the energy of the charged particles in the average home TV picture tube. Due to their potentially large population, such particles may even be dominant in producing geophysical effects.

The second approach to the measurement of charged particle activity is the use of a space probe in orbit around the moon, to detect the clouds of solar particles as they sweep across the moon's orbit, and, in cooperation with measurements from an earth satellite, to measure the velocity of the solar particles. Still another approach to be followed in 1960 is the rocket launching of recoverable film, or nuclear emulsions, into the polar atmosphere during unusual solar activity, so that the responsible particles may be identified by studying their photographic tracks. Such identification is as positive as that of an individual by his fingerprints.

Such effects have a practical aspect. It has been suggested that the arrival of large numbers of solar particles may trigger major weather disturbances. For example, on February 10, 1959, a large solar flare was followed by magnetic storms, radio disturbances, a red aurora visible as far south as Washington, record high temperatures in the Arctic, and freezing snow throughout large areas of the South. Although this one event could have been coincidental, a study of weather statistics for other years has shown a definite correlation between magnetic storms and rising polar temperatures five days later. Tree rings and wheat price index both show an eleven year cyclic weather variation, corresponding to the sun spot activity cycle. More knowledge of such phenomena could lead to the future use of data transmitted from a distant satellite observatory to predict the arrival of a cloud of solar particles in time to light the smudge pots in Florida.

The importance of the sun to man, and the immediate value of the knowledge of sun-earth relationships, is clear. But, underlying such relationships is an even more fundamental matter, that of the nature of the entire universe. Science is based on the assumption that all activity is governed by universal laws which apply both near at hand and in the remotest part of the universe. These laws form the basis for the origin and development of living matter.

All the achievements of science in the last century have been applied to the development of a remarkable description of the universe and its elementary constituents. The development begins with the neutron, proton and electron; these are the fundamental building blocks of the universe. Neutrons and protons are bound together tightly to form the atomic nucleus. Atoms consist of electrons bound to the nucleus and circling around it at some distance, like a planetary system in miniature. Atoms combine to form molecules, which in turn are cemented together to form visible matter as we know it. Our earth is a collection of such matter, circling around the sun along with the eight other known planets. The sun is one of the 100 billion stars of our disc-shaped galaxy whose cross-section we know as the Milky Way. In turn, the galaxies tend to collect in huge clusters which together make up the universe.

This entire hierarchy is built on three basic forces:

(1) Nuclear force, the most powerful force known, which clamps together the nucleus of the atom so tightly that one cubic inch of nuclei (such as is found in white dwarf stars) weighs one billion tons.

(2) Electromagnetic forces, which bind electrons to nuclei, atoms into molecules, and molecules into gross matter. These forces are some one hundred times weaker than nuclear forces.

(3) Gravitational force, which gives man weight and holds the solar system together. This force is $10^{40}$ times weaker than the nuclear force.

The weakness of the gravitational force can be illustrated by the smallness of an electromagnet which will lift a one pound iron bar, compared with the tremendous size of the earth which generates one pound of gravitational force on the iron.

Strangely enough the formation and evolution of stars depend upon the interplay between the weakest and strongest of these forces. Initially, stars are probably formed out of condensation of the interstellar dust in space. Once begun, gravitational attraction accelerates the condensation process until the pressure and temperature at the center are high enough to initiate a thermonuclear reaction whose heat prevents further attraction. The rest of the star's life history depends only on its initial mass and on the relative amount of different elements present; i.e., its chemical abundance. The determination of this chemical abundance of stars is one of the most basic problems in the study of stellar evolution.

Perversely enough, the light which contains the best information on chemical abundance on stars is beyond the visible portion of the spectrum in the ultraviolet; but such wavelengths cannot penetrate the earth's atmosphere. Thus, for the first time, man can obtain this vital information from an observatory located on an artificial or natural earth satellite. The very first ultraviolet experiments, flown by scientists of the U. S. Navy in rockets, disclosed many sources of ultraviolet light, some at locations where there is no visible emitter of light. The nature of such ultraviolet sources is still a mystery. Their further study from an orbiting astronomical observatory is an objective of the highest scientific priority which may be expected to produce new information concerning the structure of the universe.

Just as stars may have formed by the condensation of interstellar matter, so planets may have formed by the condensation of smaller pockets of matter left over from the stellar formation. If this condensation theory is the correct one, then planets such as ours must be very commonplace in the universe. On the other hand, it is possible that our planets were born catastrophically, in a rare collision between our sun and a second star. Since the probability of such a collision is extremely small with the existing stellar population, the catastrophic theory implies a small probability of other planets in the universe, and a correspondingly small chance of life existing outside of our solar system.

If we can determine what the temperatures of the moon and planets were at the time of their formation, we will have gone far toward discriminating between the condensation and catastrophic theories of the origin of the solar system. For if these planets were formed by the cooling of hot masses of solar gas, they must have passed through a molten phase; while if they were formed by the condensation of relatively cool gas or dust, they may never have existed in the molten stage. This is particularly true of the moon, which is small enough so that the heat produced by decay of radioactive uranium can be lost to its surface rapidly enough to keep the temperature below the melting point. In this respect, the moon is of greater interest than either Mars or Venus.

Another reason for concentrating on lunar observations is the uniqueness of the moon as the only major accessible body whose surface has been unchanged for a major portion of its life, some three billion years. This is due to the combined lack of mountain building and lack of erosion by air or water.

Thus, our first need is to come close enough to read nature's handwriting on the lunar surface. Television cameras in orbit about the moon or enroute to a crash landing can radio back detailed information of the lunar surface characteristics, while observations of a lunar satellite orbit can detect whether or not the moon has a "raisin bread structure" of iron chunks embedded among lighter rock, which would indicate a process of accretion from small cool masses. Television reconnaissance can also be used to select a location for the first soft lunar landing, and to obtain information concerning the nature of the surface.

Once a soft landing is feasible, instruments such as the seismograph can be placed on the lunar surface to detect moon quakes produced internally or by metorite impact. A gravimeter can measure minute changes in the lunar shape produced by the earth and sun, thus measuring the elasticity and viscosity of the moon's interior. Measurement of the surface heat flow and radioactivity would fix the temperature history of the moon within narrow limits, thereby further defining its mode of initial formation.

Again we find a coherent pattern in our search for the origin of the universe. Experiments on the interaction between radiation and matter, on relativity theory, and on gravity, lead to an understanding of the working of the universe today. Exploration of the moon and planets, together with observations of the sun and the rest of the universe, will help determine how the universe began and how its stars and planets were formed. All of these diverse activities and many others contribute to the one great inspiring objective: to understand the universe of which man is such an infinitestimal, but important, part.

One of the most exciting possibilities of space research is the opportunity to search for life outside of the earth and its atmosphere. Were one to discover life forms on another planet like Mars or Venus, the philosophical implications would be tremendous. Working on the earth and in the laboratory, the bioscientist has progressed toward an understanding of how material life may have formed on earth. Our understanding of the origin of life might make gigantic strides forward if we could discover and study, at the same time, different life forms that have developed and currently exist under different conditions.

The primitive atmospheres of Venus and Mars were doubtlessly similar to ours, but not identical with it, and the development of life on these planets, if it did occur, may be presumed to have proceeded along somewhat different lines.

The practical consequences of this research of planetary biology will require a longer time to develop, because the acquisition and interpretation of the basic facts are both very difficult. But in the long run, such research can be expected to have a greater influence on human welfare than any other area of the space sciences program. Most diseases today are regarded as essentially metabolic, that is, as due to aberrations in the normal pattern of molecular interactions. It is precisely these interactions which we hope to understand better through our biological studies of other planets.

Mars and Venus are the solar planets, other than the earth, which appear to offer the greatest probability of the development of life. The manned landings required for thorough exploration of these planets will not be possible for many years to come. Meanwhile, a progressive program of instrumented planetary explorations will be undertaken as rapidly as the necessarily sophisticated guidance, communications, and soft landing techniques become available.

At present, balloons capable of lifting heavy infrared spectroscopes to altitudes of ten to twenty miles above the earth can acquire valuable information on Venus and Mars atmospheric constituents and on the nature of some Martian surface compounds. During 1959, an Office of Naval Research sponsored experiment discovered water vapor in the atmosphere of Venus. Early space probes will develop long range communications techniques, measure the characteristics of the interplanetary environment, and observe those features of the planets, such as their magnetic fields and radiation belts, which may be expected to extend into space many times the planetary diameter.

During the past year, as shown in Table 1, a number of important scientific discoveries have already resulted from the NASA Space Sciences Program. With regard to the Van Allen radiation belts, it has been discovered that that the extent and intensity, particularly of the outer belt, fluctuates over a very wide range. These fluctuations show a distinct correlation with activity on the sun, and a complex structure which varies with time. As usually occurs in scientific research, such discoveries raise as many or more questions than they answer.

The last of the Vanguard satellites has disclosed deviations from their expected values of the earth's magnetic field, and some fluctuations in the measured magnetic field intensity with time. Again, such results raise questions regarding the sources and causes of these deviations and fluctuations. It should also be recalled that three successful satellites were launched during the latter half of 1959 and, since six months to a year is usually required for thorough data analysis, most of these data will be translated into new discoveries in 1960. If all goes as planned, Explorer VII will continue to radio back data for another nine months.

Several important results also resulted from the NASA sounding rocket program during 1959 (Table 2). Perhaps the most notable of these resulted from the Wallops Island launching of rockets carrying sodium, which was visible over a wide area of the East Coast. The resultant sodium vapor clouds showed very strong wind shears at altitudes between 70 and 100 miles, and wind velocities at slightly higher altitudes in excess of 400 miles per hour. During 1959, there were also several very successful tests of new satellite instrumentation for direct measurements of the structure of the charged region of the atmosphere which is called the ionosphere.

Table 3 summarizes the planned NASA rocket launchings through the end of fiscal year 1961. Since each sounding rocket is generally devoted to only one or two scientific disciplines, it is convenient to divide them according to their scientific purpose. The planned level of activity of approximately one hundred sounding rockets per year is only slightly less than that reached during the peak of activity during the eighteen-month International Geophysical Year, when two hundred sounding rockets were launched by this country.

During 1959, four scientific satellites were launched successfully (Table 4). Two of these utilized the Vanguard launching vehicle, one the Thor-Able combination, and one the Juno II vehicle. These launchings completed our participation in support of the International Geophysical Year by means of scientific satellite research.

During 1960, the Juno II scientific satellite program will be completed with the planned launching of four additional satellites (Table 5). The first and fourth of these missions represent follow-on studies to earlier exploratory experiments. The second and third of these missions are first exploratory experiments.

The five scientific satellites listed in Table 6 are planned to be launched with the use of the Thor-Delta vehicle system over the next two years. The last three of these missions represent first exploratory satellite experiments in their respective scientific fields, and will be launched in orbits across the polar regions.

By Fiscal Year 1962, it is expected that the solid-propellant Scout satellite launching vehicle will have been developed for routine use in the scientific satellite program. This vehicle will be put to frequent use in support of our international cooperative program in space sciences (Table 7). Like the Delta satellite system, most of the Scout scientific satellites will be launched in orbits over the earth's polar regions, with the exception of those satellites primarily devoted to the astronomical program.

The satellites which have been discussed thus far are all limited to maximum payload weights of the order of a few hundred pounds. Beginning in 1962, the Atlas-Agena and Thor-Agena vehicle systems will be capable of placing into orbit scientific satellites weighing 1000 pounds and more. Two such satellites are planned to be launched into orbits over the polar regions of the earth for various geophysical studies, as shown in Table 8. A Thor-Agena satellite will be used in a relatively low altitude orbit of several hundred miles, while an Atlas-Agena will be used in a highly eccentric orbit reaching many tens of thousands of miles from the earth's surfact at its highest point. The other two Agena satellites will be launched into orbits of relatively low inclination to the equator, one to correlate relations between solar activity and phenomena in the earth's atmosphere, and the other to make astronomical observations using a highly precise stabilized astronomical platform. This last satellite will weigh several tons.

During 1959, the first United States space probe to escape the earth's gravitational control and go into orbit about the sun was launched on March 3. This payload produced valuable information regarding the radiation belts, and was tracked to a distance of 407,000 miles from the earth (Table 9).

During the next two years, in addition to their use in the scientific satellite program, four Scout vehicles will be used to launch scientific probes which are intended to reach altitudes of from 5000 to 10,000 miles. These probes are listed in Table 10.

These comparatively short-range Scout probes which fall back to the earth should be distinguished from the longer-range lunar and interplanetary probes which are scheduled during the same time period, as shown in Table 11. Initially, relatively light-weight space probes will utilize the Thor and Atlas boosters with the Able and Delta upper-stage systems, for preliminary research on the interplanetary environment and for tests of long-range communications. Beginning in 1961, the heavier Atlas-Agena system will also be available for this important program. The first two Atlas-Agenas will be used for the twin purposes of measuring the interplanetary environment and for developing the necessary technology for more advanced missions. The last three of these vehicles will concentrate on the measurement of the surface properties of the moon.

In Fiscal Year 1963, using the Atlas-based Centaur vehicle system, we will be ready for our first attempted orbit toward the planets Venus and Mars. The objectives of technological development for later, more advanced missions and an investigation of both the planetary and interplanetary environment will be served by these missions.

In summary, the space sciences program over the next several year will include approximately one hundred sounding rockets per year, some nine satellites and Scout probes, and approximately four deep space probes for lunar and planetary explorations (Table 12). Nearly half of the requested funding in the space sciences area will be devoted to lunar and planetary explorations, while the sounding rocket program will require less than ten percent of the total (Table 13).

## TABLE 1

## RECENT DISCOVERIES IN SPACE SCIENCES

| Area | Discovery | Questions Raised |
| --- | --- | --- |
| Radiation Belts | Outer belt extent and intensity fluctuates | Causes |
| | Correlation with solar activity | Mechanism |
| | Complex structure | Explanation |
| Magnetic Field | Deviations from expected values | Source |
| | Fluctuations with time | Causes |
| Upper Atmosphere | Very strong wind shears at 70-100 miles | Cause |

TABLE 2

SCIENTIFIC SOUNDING ROCKET LAUNCHINGS -- 1959

| Date | Vehicle | Experiment | Comment |
|---|---|---|---|
| August | Nike-Asp | Sodium Vapor, dawn | High winds, 400-500 knots, 150 kilometers |
| September | Aerobee-150 (2 rockets) | Ionosphere Measurements Instrument Development | Successful tests of new satellite instrumentation, new ionospheric data |
| November | Nike-Asp | Sodium vapor, twilight | Powerful wind shears around 110 kilometers |

TABLE 3

SOUNDING ROCKETS

| | FY 60 | | FY 61 | | | |
|---|---|---|---|---|---|---|
| QUARTERS | 3 | 4 | 1 | 2 | 3 | 4 |
| ATMOSPHERE | 3 | 4 | 4 | 4 | 3 | 3 |
| SYNOPTIC ATMOSPHERE | 2 | 2 | 9 | 9 | 6 | 6 |
| IONOSPHERE | 2 | 2 | 2 | 2 | 2 | 2 |
| ENERGETIC PARTICLES | 2 | 6 | 2 | 1 | 3 | 2 |
| MAGNETIC FIELD | -- | 5 | 1 | -- | 2 | 3 |
| ASTRONOMY | 6 | 8 | 8 | 8 | 6 | 6 |
| SPECIAL | 10 | 3 | 3 | 1 | 2 | 2 |
| TOTAL | 25 | 30 | 29 | 25 | 24 | 24 |

TABLE 4

SCIENTIFIC SATELLITES - 1959

| Name | Month | Vehicle | Experiments |
|---|---|---|---|
| Vanguard II | February | Vanguard | Cloud Cover |
| Explorer VI | August | Thor-Able | Radiation belt, magnetic field, micrometeorite, radio propagation, cloud cover |
| Vanguard III | September | Vanguard | Magnetic field, solar X-rays |
| Explorer VII | October | Juno II | Composite Radiation |

## TABLE 5

## JUNO II SCIENTIFIC SATELLITES

| FY | (Quarter) | Mission |
|---|---|---|
| 60 | (3) | Radiation Belt Studies |
| 61 | (1) | Ionosphere Properties |
| 61 | (2) | Gamma and Cosmic Rays |
| 61 | (2) | Ionosphere Beacon |

## TABLE 6

## DELTA SCIENTIFIC SATELLITES

| FY | (Quarter) | Mission |
|---|---|---|
| 61 | (2) | Solar Spectroscopy |
| 61 | (3) | Radiation Belt Studies |
| 62 | - | Atmospheric Structure |
| 62 | - | Geodetic Flashing Light |
| 62 | - | Ionosphere Topside Sounder |

TABLE 7

SCOUT SCIENTIFIC SATELLITES

| FY | Mission |
|---|---|
| 62 | International |
| 62 | Polar Ionosphere Studies |
| 62 | International |
| 62 | Polar Radiation Studies |
| 63 | International |
| 63 | Polar Atmospheric Structure |

## TABLE 8

### AGENA SCIENTIFIC SATELLITE

| FY | Booster | Mission |
|---|---|---|
| 62 | Thor | Polar Geophysics |
| 63 | Atlas | Geophysical Observatory |
| 63 | Thor | Sun-Earth Relations |
| 63 | Atlas | Astronomical Observatory |

## TABLE 9

## SPACE PROBE - 1959

Pioneer IV

March 3

Juno II Vehicle

Energetic Particles Experiment

Communications Tests

Tracked for 82 Hours to a Distance of 407,000 Miles

Now in Orbit About the Sun

## TABLE 10

## SCOUT SCIENTIFIC PROBES

| FY | (Quarter) | Mission |
|---|---|---|
| 61 | (2) | Ionosphere Structure |
| 61 | (3) | Nuclear Emulsion Recovery |
| 61 | (3) | Ionosphere Structure |
| 62 | - | Outer Atmosphere Winds |

TABLE 11

LUNAR AND INTERPLANETARY PROBES

| FY | (Quarter) | Vehicle | Mission |
|---|---|---|---|
| 60 | (3) | Thor-Able | Interplanetary Environment and Communications Tests |
| 61 | (1) | Atlas-Able | Lunar Orbiters |
| 61 | (2) | Atlas-Able | |
| 61 | (2) | Delta | Interplanetary Plasma and Field |
| 61 | (4) | Atlas-Agena | Interplanetary Environment Technological Development |
| 62 | - | Atlas-Agena | |
| 62 | - | Atlas-Agena | Lunar Surface Properties |
| 62 | - | Atlas-Agena | |
| 62 | - | Atlas-Agena | |

## TABLE 12

## SPACE SCIENCES VEHICLE SUMMARY

| | FY 60 | FY 61 | FY 62 | FY 63 |
|---|---|---|---|---|
| Sounding Rockets | 55 | 102 | | |
| Scientific Satellites and Scout Probes | 4* | 9 | 9 | 5 |
| Lunar and Planetary Explorations | 2** | 4 | 4 | 2 |

* Includes 3 in orbit

** Includes one launch failure

## TABLE 13

## SPACE SCIENCES BUDGET SUMMARY

(In Millions of Dollars)

| | FY 59 | FY 60 | FY 61 |
|---|---|---|---|
| Sounding Rockets | 3.9 | 8.8 | 8.0 |
| Scientific Satellites | 21.3 | 22.8 | 41.7 |
| Lunar and Planetary Explorations | 30.2 | 49.0 | 45.0 |
| TOTAL | 55.4 | 80.6 | 94.7 |

FOR RELEASE UPON PRESENTATION

Statement of Richard E. Horner, Associate Administrator
National Aeronautics and Space Administration
before House Committee on Science and Astronautics

Mr. Chairman and Members of the Committee:

It is my purpose to extend the remarks of the Administrator and Dr. Dryden by discussing with you the Ten-Year Plan of program activity in space experiments that we have developed, and relate to it the financial resources that we are currently using and those we are requesting authorization for at this time. I will also set forth our other resources in terms of the organization, personnel, and facilities that are essential to the implementation of the space effort.

You realize, of course, that during the last sixteen months all of our planning has proceeded simultaneously with our efforts to create a functioning organization and the initiation of major scientific and developmental programs. It will appear obvious to you, I am sure, that whereas our plans reflect the lessons of our intensive recent experience their extrapolation into the future becomes more tenuous as the years become more distant. And, of course, any planning which must be supported by fiscal year budgets beyond the one currently under request for authorization must, of necessity, be recognized as dependent upon the many and various influences of Government operations in the future. In addition, and completely aside from the relative brevity of our experience and the uncertainty of financial resources that might be available in the future, there must also be taken into consideration the well recognized fact that the nature and depth of future research and development efforts in any complex technical field are heavily dependent upon the character of prior accomplishments. Stated simply, our successes or miscues of this year will have a commanding influence on the integrity of our plan for next year.

Having explained the uncertainties of a long term plan, I will now turn to the reasons for having one. Virtually all of our key programs presume a scheduled progress in launch vehicle and spacecraft development. These major developmental tasks frequently require time periods of five to six years for completion and can be substantially longer under given circumstances of technological progress and resource availability. Thus, although the usefulness of highly tentative plans might be questioned, long-term objectives, on the order of ten years in advance of today's program, are essential to keep our development activities properly focused. The actions we initiate this year and next in the vehicle development program will have a determining influence on our capabilities for meeting national objectives in the last half of this decade and even beyond. Accordingly, we have developed a Ten-Year Plan, one which we expect to modify from year to year on the basis of realized experience, development progress, and resource availability. It is formulated around the requirement that its implementation must so utilize the resources of the United States that our national role as a leader in the aeronautical and space sciences and their technologies is preserved and steadily enhanced. We have also assumed that a steady growth in the scale and intensity of our efforts, especially for the next five years, is an essential basis for consistent and fruitful efforts in meeting this requirement.

The initial step in constructing the plan was a projection of attainable growth in our capability to launch into the space environment spacecraft of increasing size, versatility, and technical sophistication. The first chart shows the anticipated growth in spacecraft weight from year to year during this ten-year period. Here I need to define spacecraft as that portion of the vehicle, including the propulsion and attitude controls and guidance units for maneuvering, which is designed to be placed into orbit about the earth or onto a departure trajectory departing from the earth. For the purposes of comparison, on this chart the capabilities of launch vehicles are measured in terms of the weight that can be projected into a low altitude earth orbit of about 300 miles. You will note that the increasing capabilities in the early years come through the successive utilization of the Thor-Agena B, the Atlas-Agena B, and the Atlas-Centaur.

In the 1963-1967 time period, our increasing capability will be primarily attributable to the use of the Saturn first stage and successively improved upper stages based on employment of liquid hydrogen and liquid oxygen. You will note that by 1967 we will have gained the capability of placing payload weights in low earth orbits of about twenty-five times the magnitude of those available today. I hasten to emphasize that the requirement for payloads of these weights in such orbits is limited, but remind you that I am using this figure as a convenient comparison and the increasing performance represented will be necessary to project needed payloads on more difficult missions to the plants and to high earth orbits. The rate of growth indicated here is consistent with our foreseen potential for technological progress and is attainable provided adequate resources are applied. It is clearly necessary if the vigorous program which will attain national objectives is to be implemented.

To further define the framework of this plan, I would like to consider now our projected launching schedule which is illustrated here in the general terms of the numbers of each vehicle launching which occurs in the next six quarters and for each fiscal year thereafter during the decade. You will note that in fiscal year 1962 and beyond, the present variety of first stage launch vehicle types will be reduced to one solid propellant rocket, the Scout, and three liquid propellant rockets, the Thor, the Atlas, and the Saturn. This number might very well be reduced further by eliminating Thor vehicles earlier than is indicated in this chart. The Agena B and the Centaur will become our utility second stages until larger high energy upper stages come into use on the Saturn in the time period fiscal year 1965 and beyond. This restriction of the number of vehicle types is planned in the interest of increasing reliability through more intensive experience with each of a limited number of systems. Beyond the capability of the Saturn series of vehicles, we have provided for the introduction of a vehicle, the Nova, with four to six times the first stage thrust based upon the one and one-half million pound F-1 engine currently under development. We foresee the beginning of development testing on such a vehicle in 1968. Our total launching and space flight capabilities are being developed to the point where it is anticipated that a program of more than two launches per month will be conducted for major application and exploration missions in space.

The spacecraft capacity and the planned launching schedule are both a prerequisite for and a product of the intended missions to be accomplished. The interplay between such schedules is obvious in this next table of mission target dates. In some respects this listing might be considered a key indication of the proposed rate and scale of our space experimentation effort. Again it is apparent that the year which is immediately ahead of us is subject to more definitive planning than succeeding years and the activities of the latter part of the decade can only be characterized by the most outstanding of planned objectives. Needless to say there are many space experiments of real significance which do not appear on this listing and the "first launching" terminology generally indicates in each instance a beginning of a series of space vehicle operations. In the current year is reflected the beginning of tests of several vehicle development programs as well as the first orbital experiments in both meteorology and communications. You will also note the scheduled first suborbital flight of an astronaut, boosted more than 100 miles into space with a Redstone vehicle. In the calendar year 1961 we are working toward the launching of a sophisticated lunar impact vehicle and a further step forward in our vehicle development program with the initiation of flight tests on the Centaur.

Assuming continued success in the complex schedule of tests for Project Mercury, the first orbital flight of a manned space vehicle will also occur in calendar year 1961. From there we go through the ten-year period with a comprehensive program of exploration of the moon and the near planets and developing the Saturn launch vehicle to provide necessary information and capability for the beginning of manned circumlunar flight in the latter part of the decade. It appears to be clear, from a careful analysis of launch vehicle requirements as we now understand them, and information yet to be developed that a manned landing on the moon will fall in the time period beyond 1970. These are the major milestones in our long range plan for space exploration and the application of space vehicles.

Let us look now at the resources which our studies to date indicate to be essential for meeting these objectives. Before I turn to a specific consideration of our current budget authorization request, I would like to make a few generalized comments about future year financial requirements. The many uncertainties related to a complex technological program such as the one with which we are dealing -- unanticipated scientific advances -- developmental difficulties, as well as the even more obscure influences of national financial policies and economic trends as a whole -- make specific predictions as to total requirements for fiscal year 1962 and beyond speculative to the point of being worthless. However, it can be said that in view of the half billion dollar obligation rate during the current year and the proposed $802 million program for fiscal year 1961 it is likely that a natural growth of the developments now under way will lead to a budget request of more than one billion dollars in the following year with a growth to more than one and one-half billion dollars a few years later.

Now, if I may, I would like to turn to our authorization request for new obligating authority in fiscal year 1961. As I have already mentioned the total request amounts to $802 million. It is divided into three major functional areas of our activities as shown on this chart. For salaries and expenses there is allocated $167,560,000. These are the total charges for travel, communications and utilities as well as salaries and other miscellaneous personnel expenses. For research and development the figure is $545,153,000. From this account all project activity is supported, including purchase of materials and parts, as well as disbursements for development contracting. Of course, our investment for research grants and contracts is also provided for in this figure. You will note that this category of funds constitutes substantially more than two-thirds of our total budget request. The members of the NASA staff who follow me will discuss in detail the individual development programs which are supported with funds from this area.

The third kind of budget authority we seek is that for construction and equipment in the amount of $89,287,000. This money is used to create new facilities for the accommodation of the changing research and development requirements. It is the minimum essential investment to provide the pressing needs for our essential in-house project activity as well as laboratory and test facilities for the supporting research so essential as the foundation for our entire program. Although the National Aeronautics and Space Administration inherited a substantial complex of excellent facilities at the existing NACA laboratories, the space exploration program demands a continuing investment to modernize and convert existing facilities as the requirements evolve, and construct entirely new facilities where new technical disciplines in research or testing must be covered.

Of the current request, 25 percent is for provision of facilities at our research centers to make possible the continuing supporting research program described to you by Dr. Dryden. The balance of the facilities requested are directly in support of space experimentation, most of it at the three space flight centers and the Cape Canaveral launch site. You may find it desirable to develop additional information concerning individual facilities. We will be happy to respond to your questions as you see fit.

To properly consider the budget request of the current year, it is interesting to compare it with the resources provided in past years. This chart provides an easy comparison of the magnitude of the NASA programs in fiscal years 1959, 1960, and 1961. As indicated the fiscal year 1960 number will be increased by $23 million if the Congress sees fit to grant our current request for supplemental appropriations. As I have indicated previously, the budget figures indicate a rapidly expanding program. The rate of expansion, however, is not a natural growth of the needs of the development program, since, in each of the last two years, substantial new responsibilities have been assigned to NASA as our national space effort has been identified and organized. For example, during the past year, the assignment of development responsibility for super boosters has resulted in a major addition to our fund requirements.

This rapid rate of growth has extended our management capability to the limit of its capacity. Extra hours and added assignments have become the rule of conduct for our staffs both at the Washington Headquarters and at the field centers. We have, however, been able to substantially maintain the work schedules and, if occasional development failures bring severe disappointment, they also bring added determination on the part of all, to bring success to the highly diversified and broadly cast program we have initiated. In the area of financial management you will be interested to know that substantially all of the money appropriated for program support in fiscal year 1959 has been obligated to project activity. The program implementation performance has been equally satisfactory during the current fiscal year with funds being committed at the scheduled rate. I would like to assure you that this is not just a process of commiting funds as the schedule dictates but each contract and procurement action is the result of a carefully considered analysis usually based on extensive scientific study and program correlation.

I would like to turn now to a consideration of other categories of resources which are essential to our program implementation. These include organization, facilities, and manpower. As you know, the overall complex of our organizational structure has been created largely by the integration of existing organizations and parts of organizations into the present National Aeronautics and Space Administration. The nucleus was provided by the 8,040 staff members of the laboratories and the headquarters of the NACA. To this were added 400 members from the Vanguard team, transferred from the Naval Research Laboratory. Seven hundred new positions were provided in the first fiscal year, and an additional 700 in the current fiscal year to round out the staff and provide technical and scientific skills that were not present in the older laboratories but are required for this new business of space exploration. The proposed budget program reflects an additional increase to a total strength of 16,373 in the Administration, but here again almost 90 percent of the increase results from the assimilation of a single group, that of the Huntsville, Alabama, agency, under the leadership of Dr. von Braun. The remaining fraction of the growth is needed to balance the skills of the organization and to properly effect the integration. In this process of rapidly assembling existing groups into a coherent and effective organization, while concurrently developing a complex program of unusually high scientific and technical content, and at the same time carefully interlacing and coordinating our efforts with other Governmental, scientific, and industrial organizations, it has been understandably necessary to increase our Headquarters staff. We recognize that at least part of the work burden at the Headquarters is interim in nature and we therefore strongly resisted expanding beyond what we foresee as the longer term needs of a more stable organization and program growth. The net result, as I mentioned earlier, has been long hours in concerted effort by most of our staff. We scarcely see how we could have accomplished our objectives, without the staff growth that has been realized nor can we anticipate proper performance with less than the stated requirements in the budget authorization under consideration.

With the added work load of the recent assignment of responsibility for development of super boosters, an addition to the Headquarters staff is required. Recognizing the absolute essentiality of attaining the best possible launch vehicle performance in terms of timely availability of load lifting capacity, and paying respect to the resulting need for reducing the number of types of launch vehicles in order to optimize reliability, the staff function of directing launch vehicle development and operations has been separated from the balance of the space flight programs. This has resulted in the functional staff organization at Headquarters as we see on this chart. Aside from the Office of the Administrator and the special staff offices he requires, the four functional staff elements now include the Office of Business Administration, the Office of Advanced Research Programs, the Office of Space Flight Programs, and the new Office of Launch Vehicle Programs. The total staff strength intended is 16,373 people. [It is the policy of the Administration to delegate all responsibility for program implementation and detailed program initiation to the field centers.] Functional areas of responsibility have been assigned to each of the centers, and I believe it is worthwhile to discuss each of them briefly.

You may note their geographic location on the large map at my left and their channel of communication and responsibility to the Headquarters staff is indicated on this chart.

The Langley, Lewis, Ames and Flight Research Centers are the laboratory centers which constituted the research capability of the National Advisory Committee for Aeronautics. Organizationally and for program integration purposes they report to the Office of Advanced Research Programs in the Headquarters. Although their individual staff levels have been stabilized for the past few years and the proposed staff strengths for fiscal year 1961 exactly coincide with the fiscal year 1960 staff numbers, the program of work at each of these centers has undergone a major change in the past one and one-half years. Whereas, by far the bulk of the work of two years ago was oriented toward the current and advanced needs of aeronautical developments, the combination of significantly reduced numbers of aircraft development projects in the United States and the needs for research in support of the space flight program have rapidly shifted the emphasis of research efforts at the centers to the astronautics end of the spectrum. This change has resulted in substantial problems for our research center staffs in reorganizing and retraining for the new tasks, hiring in new technical disciplines as the effort in areas of waning interest is decreased, the modification of old facilities and the creation of new to accommodate the new research regimes. This reorientation is progressing at a very satisfactory rate.

Having explained some of the problems of reorienting the in-house research program, I would now like to emphasize that although the total effort in aeronautics has markedly decreased there is still very important work being conducted in this research area. The very low speed regime of flight is being extensively investigated in wind tunnels and by actual flight tests to explore the possibilities of vertical take-off and landing craft as well as those which have very short take-off and landing characteristics. As long as there is a continuing interest in the Department of Defense and the possibility of industrial application there are likely to be continuing research requirements in this area.

At the other end of the spectrum of flight within the atmosphere, there are still challenging research problems to be solved in connection with supersonic and hypersonic flight. Of course many of the hypersonic flight problems are equally applicable to space vehicles, for the departure and re-entry phases of flight from and to the earth. The work in high speed aerodynamics, materials and aircraft operating problems are, however, some areas in which there is continuing interest for development of high speed military aircraft and missiles, and possible application to supersonic commercial transports. Further, the NASA facilities stand ready to support specific applied research should additional developments of high speed aircraft indicate the requirement.

Now let us look briefly at the individual centers. At the Langley Research Center a staff of 3,220 will conduct the research program in fiscal year 1961 at a total program cost of approximately $50,000,000. This includes the salaries for the total staff, the research and development expenses, and the cost of a major facility addition which will be able to simulate the gas temperatures and velocities which will be encountered by a space vehicle returning to the earth's atmosphere, a facility which is essential to the solution of key problems in our on-going program. Major areas of work at the Langley Research Center include research in structures and materials, the aerodynamics of re-entry vehicles, continuing work in aircraft aerodynamics and fundamental research in plasma physics. This center, which you will see from the map, is located near Hampton, Virginia, and is the oldest and the largest of the research establishments. A major portion of the research facilities, which constitute a total real investment of $154,000,000, are shown in this photograph.

The Lewis Research Center, located at Cleveland, Ohio, represents a facility investment of $148,000,000 and employs a staff of 2,736 people. An aerial view of the facilities of the center are shown in this photograph. Its primary research mission is investigation related to propulsion. Research programs are now active on chemical rockets with emphasis on high energy propellants, on nuclear rockets, and on electrical propulsion devices. Electrical power generation in support of this latter area of propulsion research also requires major attention from the center.

At the Ames Research Center, in the Santa Clara Valley of California, on the Moffett Naval Air Station, a staff of 1,440 conducts a comprehensive research program in facilities with an original construction value of $107,000,000. An aerial view of these facilities is shown in this photograph. The principal areas of work are space environmental physics, including simulation techniques, gas dynamics research at extreme speeds, and automatic stabilization, guidance and control of space vehicles. There are also under experimental evaluation at this center several full scale models of vertical take-off and landing craft.

The Flight Research Center at Edwards, California, is a relatively small but unique and highly specialized facility, shown in this photograph. On the edge of Rogers Dry Lake, it takes advantage of this 75 square mile flat surface as an ideal testing ground of research aircraft. Four hundred sixteen staff members are currently concentrating most of their efforts on the flight evaluation of the X-15. A limited number of flights have already been conducted by the contractor's flight crew. It is anticipated that center personnel will shortly begin the flight research program wherein the pilot will be propelled substantially above the earth's atmosphere and experience the characteristics of space flight for durations of a few minutes. The coming year should be of high interest in this project if the program goes as expected.

In the space flight side of the program there are three major research and development centers at work and three locations in which we have varying levels of investment for purposes of launching space vehicles. In research and development activities, as I have already indicated, we have divided the work into two categories--launch vehicle development and operations on the one hand, and spacecraft development and operations on the other.

Two centers are primarily engaged in spacecraft development and, again, a functional division in the work has provided to the Goddard Space Flight Center the primary responsibility for those projects concerned with earth orbiting craft both in their development and operation as well as supporting research and test as necessary for the mission. It is at this center that the Vanguard team served as a nucleus for a staff which is projected to grow until it numbers 2,000 with the proposed fiscal year 1961 budget authorization. The staff is currently housed in several different locations in the Washington area and at the Langley Research Center. However, the badly needed space research facilities for this center are under construction at Greenbelt, Maryland, and the first of these will become available for beneficial occupancy by the middle of this summer. The satellite and sounding rocket program, the manner space flight program, and the application of space vehicles, including passive communications and meteorology, are the major program elements of this center. Following witnesses will discuss these programs in detail, and point out accomplishments to date.

The responsibility for the other major area of spacecraft development is assigned to the Jet Propulsion Laboratory at Pasadena, California. It is the exploration of deep space, including the lunar and interplanetary flights. This Laboratory is employed in our program through the medium of a contract with the California Institute of Technology. The staff at the present time totals approximately

2700 people, including several hundred currently engaged in the systems engineering of an Army weapon, the Sergeant ballistic missile. As the activity on this weapon system is phased out, we expect some decrease in the total staff size, but our present plans indicate that a stable requirement will persist for about 2400 people. An aerial view of the facilities which the Laboratory occupies in the foothills of the Sierra Madre is shown.

It is in the area of work of this organization that one becomes most impressed with the extreme complexity of the spacecraft which must be created to carry out the interesting missions in lunar and interplanetary exploration. As I have indicated earlier, our program anticipates a major flight experiment of this kind at approximately three month intervals in the time period affected by our proposed budget. A vast amount of creative engineering is a prerequisite to each flight, and the data analysis of the quantities of information recorded also represents a tremendous task. It is clear that this work will require a major fraction of our resources in the years to come.

It is appropriate to divert here a moment and explain a principle of our program formulation in this area. The question of back-up vehicles for specific experiments has arisen frequently. This has indeed been a cogent question during the early days of our program when improvisation has been common and individual space flights have been somewhat loosely related in the fabric of our entire effort. It is our objective, however, to plan our experiments in each of the major program areas as a coherent and integrated effort. Each major experiment will be carefully related to the overall program objectives, based upon the results of previous flights, and generally increasing in sophistication as time progresses. Many of the spacecraft will in themselves be related through the use of common structural frames, power supplies, and instrumentation. There will also be many which, tho differing in their performance objectives, use launch vehicles of the same type. In such a program the best utilization of our resources is not realized by providing back-up boosters for each payload. Rather, it should be considered that a launch is scheduled periodically, in this case each three months, and if a catastrophic failure is experienced with any one launch then a determination can be made at that time as to whether a similar spacecraft should be flown on the next scheduled vehicle. The need for extensive ground testing of all spacecraft requires that spare devices be produced in each case. It is therefore possible to assemble an additionalspacecraft to replace a failure on reasonably short notice. This, I would emphasize, is a principle used in the formulation of our program. Like all such principles, it is occasionally desirable to consciously violate it where unique program requirements prevail. Thus our program is under constant surveillance to identify specific flights where a back-up vehicle would be advisable and in these cases one is provided.

The launch vehicle development and operation task is assigned to the NASA Huntsville Facility. I know you are all aware that the decision to transfer this facility to NASA was taken recently, and the plan to carry out this decision is currently before the Congress. It provides for a transfer of 5500 people under the leadership of Dr. von Braun. The development facilities which will also be transferred had an original investment cost of approximately $100,000,000. The major project activity of the group at the present time is, and for some time will be, the development of the Saturn booster and the integration of the upper stages. Dr. von Braun will provide the committee with a detailed briefing on this project. There are also numerous other activities at this center, including work on several Army missile systems, which will be carried on in accordance with the agreements we have made with the Department of Defense.

As I previously indicated, the responsibility for launch vehicle operation as well as development comes under the von Braun group. For this purpose a missile firing laboratory is maintained at the Atlantic Missile Range at Cape Canaveral, Florida, which will supervise all NASA vehicle launchings from that site and will actually carry out the launching of vehicles developed at Huntsville.

In the time period pertinent to this budget authorization request we will also have some space flight operations from the Pacific Missile Range. We plan to launch from this location all spacecraft which require Polar orbits. Although the launch operations will be carried out largely by contract, a small group of NASA technical and administrative liaison people will be located at the site.

At Wallops Island, off the Virginia coast, we have a small launching service organization which conducts the numerous launchings of our sounding rocket program and the solid propellant orbital vehicle which we will bring into service during the current calendar year. A staff of 300 people operates a facility valued at $18,000,000 which is shown in this aerial photograph. The work is largely in response to the needs of the sounding rocket and satellite program.

To round out the organizational picture, as shown in the lower lefthand corner of the chart, is the Western Operations Office. This office is established in Santa Monica, California, with a staff of about 40 people. Its function is to perform liaison with the many development contractors engaged in our program and to carry out contract administration as required. The existence of this office greatly reduces the requirement for travel to this area by personnel of the Headquarters and various other centers.

Mr. Chairman, I would like to turn for just a brief period to another subject which has been of extreme importance to us and has occupied a great deal of our attention. This is the matter of our program coordination with the space efforts of the Department of Defense. I want to emphasize, first, that we have an excellent relationship with the Military Departments and the Office of the Secretary of Defense. Program correlation and project coordination is thorough and compatible with our needs, as I believe it is with the needs of the Department of Defense. There has been a great deal of discussion about a single national space program with, I am afraid, all too little understanding of what is precisely involved in this term. The nation's space efforts can be discreetly considered in two major categories. One is space exploration, the measurement of scientific phenomena in space and on distant bodies, whether it be by the use of instrument or the human senses. The other is the application of spacecraft. Now to insist that there should be a single national space program might very well be to insist upon relating such diverse endeavors as meteorology, international communications, navigation, military reconnaissance, and space exploration. They are neither easily relatable nor sensibly compatible. It is, however, clearly possible to formulate a national space exploration program, and it is our belief that it was the intent of the Congress, as shown by the legislative history of the National Aeronautics and Space Act of 1958, that the NASA should indeed formulate such a program and proceed with its implementation. This we have done.

I make this point because its recognition is prerequisite to a workable relationship between the NASA and the Department of Defense. I have had a chart prepared which I think illustrates the coordination as it currently exists. A few facts stand out. Space exploration is the responsibility of NASA. Military applications is the responsibility of the Department of Defense. Civil applications is the responsibility of NASA. There are some applications which are of interest to both military and civil needs. The underlying research and technical development is largely useful in both programs and common use can be made of launch vehicles. Therefore, in the areas of certain applications--launch vehicle development, and background research and development--careful coordination is required to assure that full value accrues in joint utilization of either agency's products. The chart shows examples of these coordinating devices. Again, I repeat, they are working well. When undesirable duplication is identified, it is eliminated and there is tremendous pay-off in the programs of each for the benefit of the other.

I appreciate this opportunity, Mr. Chairman and Members of the Committee, to discuss these several facets of our program with you. Many of them I have covered sparsely, and together with my associates we will be glad to answer your questions to the best of our abilities.

NASA Release No. 60-111

Statement of Richard V. Rhode, Assistant Director of Research
(Structures and Materials and Aircraft Operating Problems)
National Aeronautics and Space Administration

before House Committee on Science and Astronautics

Mr. Chairman and Members of the Committee:

Many problems in applied research and technology must be solved before we can accomplish our future, more advanced space missions. A great deal of knowledge has to be obtained through the research process to establish the facts required to make a sound judgement as to the feasibility of any development project. To proceed with development in the absence of such knowledge means that we must pin our hopes on assumptions born of ignorance. This can be an extremely costly process.

In order to illustrate our research activity, let us consider a space mission designed for manned circumnavigation of the moon. This mission entails launch and exit from the atmosphere, space flight, orbiting the moon and exploration of the lunar surface, and finally, return to earth, entry into the earth's atmosphere and landing. The first phase of this or any other mission is launch and exit from the atmosphere.

## LAUNCH AND EXIT

This manned Lunar mission will require a large main booster, such as "Saturn", with suitable second stage and other boosters, and a payload consisting of a spacecraft and re-entry vehicle together with their contents.

Such a system is large and heavy. The length may be 300 feet and the weight a million pounds. Because of the great importance of weight, the structure will be light and flimsy by normal structural standards. The volume and weight of the fuel will be large. The system will be balanced on and accelerated by rocket engines having a total thrust of 1.5 million pounds, and it will be subjected not only to the force of thrust along the axis, but also to side forces caused by winds and turbulence and to the corrective sidewise components of thrust from the gimbaled engines.

With such a system, having large weights and forces and a light structure, there is a very difficult problem of vibration or system dynamics.

One aspect of this problem is the interaction between the control system and the flexible structure. This aspect, which is called structural feedback, can be demonstrated by a simple model. The control system consists of a device sensitive to motion, called a sensor, which transmits a signal to a control element. Here, the sensor is a simple accelerometer and the control element is an electro-magnetic device which causes side forces similar to those caused by gimbaled engines. When the sensor is moved by hand, the control device also moves and causes the structure to respond. In practice, the sensor must, of course, be located somewhere in the system. Suppose it is mounted amid ships and the system is disturbed as it might be when a gust is encountered in flight. The response of the structure is considerable, and in practice this much vibration would destroy the vehicle. It does not die out and is therefore called unstable.

The shape of the axis as it bends back and forth is typical of a simple bending vibration. Let us see what happens when the sensor is placed at the nose. Now a more complex form of vibration is excited. One can readily see that the interaction of a control system and a flexible structure poses a problem. As previously noted, the system contains a large mass of fuel, and the demonstration has shown that vibratory motions will cause the fuel to slosh around in the tanks, thus setting up additional large and irregular forces.

We have here a short movie sequence showing studies being made of fuel sloshing in the laboratory. You will first see a transparent tank with colored fuel reacting to control forces. This will be followed by a demonstration of the effectivensss of baffling.

The control element here is a gimbaled air jet, simulating the rocket engine, and located at the bottom of the tank. A suitable baffle helps to reduce the fuel sloshing.

These and other facets of the booster-system dynamics problem are being actively studied at our research centers by both experimental and mathematical techniques. We will have to continue to do so for some time to come, because the problems become both more serious and difficult as the systems become larger.

SPACE FLIGHT

Once the vehicle has been successfully launched into space, many new problems are encountered. Among them are the hazards of the space environment, such as meteoroids, and problems of guidance and attitude control of the spacecraft. Let us consider first the meteoroid problem.

Meteoroids are metallic or stony bodies that travel through space at speeds estimated to range between about 25,000 and 165,000 miles per hour. Some of them are very large, such as those that caused the craters on the moon, or the one that fell in Arizona centuries ago to create the well-known meteor crater there. Others are very small. Fortunately, the large ones are extremely rare--for example, the surface of the moon has not visibly changed by large-scale meteoroid impacts since the invention of the telescope. We don't worry about them any more than you worry about them when you walk down the street. As the meteoroids become very small, however, the numbers of them increase to the point where the probability of hits or impacts on a spacecraft becomes quite high. If there were no atmosphere to burn them up, we would all be likely targets for them. These small meteoroids may be only a few thousandths of an inch in diameter.

Although very small, they can, because of their tremendous speeds, be very destructive. It has been estimated, for example, that a ball in space made of aluminum about one yard in diameter and having a thickness of .005 inch might be punctured as often as once every ten hours or twice a day. With ten times this thickness, the ball might be punctured once every 200 days. Obviously, light structures, including tanks and radiators, will not give satisfactory service over a long period of time without some protection against meteoroid strikes.

One way to study this problem is to shoot small particles at high speeds at test specimens and see what happens. We have been doing this for some time.

This photograph shows two high-speed helium or light-gas guns developed at our Ames Research Center. Some of you, I understand, have seen them. They can shoot small balls about 1/16 inch in diameter as fast as 14,000 miles per hour. This speed is much faster than a rifle bullet--a typical military rifle, for example, shoots at about 2000 miles per hour. We can obtain much useful information from such equipment, because by using relatively large pellets we can obtain the same impact energy as the smaller meteoroids have. Meanwhile, we are studying means for shooting smaller particles at speeds within the meteoroid range.

This chart shows, on the left, the crater made by an actual meteoroid impact on a sounding rocket. It occurred at about 90,000 feet altitude within the atmosphere; consequently, the meteoroid must have been greatly slowed down from its original speed by the atmosphere above this level. The rocket itself was traveling at only about 3,000 miles per hour. The impact was therefore much slower than those we expect to encounter in space. Nevertheless, the incident is of great interest in demonstrating that impacts actually do occur, and in providing a rough comparison with laboratory impacts.

On the right is a photograph made in an NASA laboratory of an impact crater made by shooting a small steel ball at a copper target. You have probably seen such pictures before. This comparison simply shows the similarity of the two craters--one made by a micrometeoroid in space--the other by a particle shot from a gun in the laboratory.

One of the possible ways of handling the meteoroid threat is to build a light shell or "bumper" around the spacecraft. The thought here is that the particles are going so fast that when they strike the bumper they will disintegrate before striking the underlying structure. An idea of the possible effectiveness of such a bumper is shown in the next chart.

These are results of some studies made with one of the guns shown in the photograph you just saw.

The figure shows the speed in miles per hour required to just penetrate the target with 3/16 inch diameter Pyrex balls. We see that a pellet going at 2,000 miles per hour will go through a single thick sheet. But if the sheet is split and separated a bit, it takes a speed of 4,000 mph to go through. With four layers, again of the same total weight, we can withstand somewhat greater speed. And if we fill the space between the bumper and the second sheet with low-density, glass-wool, we see that particles going as fast as 7,000 miles per hour will be stopped. These tests simulate what would happen with meteoroids 1/16 inch diameter at speeds of about 40,000 miles per hour--well within the meteoroid speed range.

The results and conclusions I have just shown you are based on laboratory tests, and of necessity contain some assumptions and approximations. We would like to get some direct and actual data from real meteoroids. To do this, we plan to send up a test satellite this year on one of our first Scouts to test out the theories and laboratory results.

This is a 1/5th scale model of the puncture-experiment satellite. The short tubes running lengthwise will be made of metal of various thicknesses, and will contain gas under pressure. When a tube is punctured by a meteoroid, the gas will leak out and this occurrence will be radioed back to earth. In this way, we will get direct information on how long a structure made of material of different thickness can be expected to last out in space. In the future, we will get more and more direct information of the sort that will enable us to design better and more efficient spacecraft.

Another problem of space flight is that of guidance and attitude control. I shall review a few aspects of this problem.

Many satellite and other space missions, such as our Lunar mission, require that the attitude of the spacecraft be maintained or stabilized. On this chart are shown some typical requirements of attitude control. Earth satellites might be required either to continue to point toward the center of the earth or to continue to point toward a fixed object in space. Space probes or space ships taking navigation fixes must, in general, point toward some fixed object in space.

Different missions require different degrees of precision. Earth-oriented communications and meteorological satellites require relatively little precision--the attitude need be maintained only within about 8 degrees for the former, and within about one degree for the latter. Space-oriented spacecraft however demand a very high degree of precision. Interplanetary navigation, for example, requires that the attitude be stabilized within about .005 degrees, and the astronomical satellite must be stabilized to the very fine point of .0003 degrees. In order to give some idea of what this means, .0003 degrees is the angle contained between two straight lines starting at a point in this room and spreading only 70 feet apart in San Francisco.

Spacecraft stabilization systems may differ in the specific means employed to do the job. All of them, however, must employ mechanisms of one kind or another to perform the required functions. These functions are to sight on some reference point, such as the Lunar horizon or a star; analyze the information from this sighting system or sensor, and to activate a suitable control device in order to maintain the proper attitude of the spacecraft.

Here is a simple demonstration model of an attitude control system. The spacecraft is represented by the turntable, which is free to rotate just as the spacecraft is free to rotate about any of its axes. The sensor is a simple photo-electric cell. Its signals actuate the control device, which in this case, is an inertia wheel that operates on the principle of conservation of angular momentum. As you see, when the platform is turning slowly, the light source will stop the rotation and the sensor will continue to point at the light. All of the mechanism for doing this is self-contained on the turntable and no external force is applied.

In order to obtain the required precision, each one of the functional requirements must be subjected to the research process such as indicated by the work going on in this laboratory set-up. For example, if as is likely, the sensor is a light-sensitive mechanism, its sensitivity and accuracy must be investigated in relation to the wave lengths available in the light source; some of the wave lengths may have to be filtered out. Again, control mechanisms of various types must be investigated to determine the principles best suited to the development of controls having low power requirements and at the same time high positioning accuracy. These and many other problems are being investigated with laboratory equipment such as shown on this chart.

Progress to date indicates that we can achieve an accuracy of three hundredths of a degree with present laboratory equipment, and that 1-1/2 hundredths of a degree can be achieved before long. Further research is obviously required in order to develop the high accuracies required for space-stabilized systems.

## LUNAR EXPLORATION

The third phase of our assumed mission is to circumnavigate the moon and conduct the necessary exploratory activities. We would expect the men aboard the spacecraft to be taking moving pictures and television pictures and performing other observations. This gets us into the question of weightlessness and whether men can perform the required duties in a gravity-free environment. As this question of zero g has been touched upon by others, I shall not go into it.

Another aspect of Lunar exploration is the matter of sending instruments to the Lunar surface and to have them remain intact so that they can transmit information either back to the spacecraft or to Earth. To do so requires ejection of a lunar landing system and instrument package from the spacecraft, arresting its forward motion and placing it on the moon intact.

In principle, there are several ways in which this can be done. You are all familiar with proposals that have been made to lower a suitable container to the Lunar surface by means of retro-rockets, such as indicated at the left on this chart. This kind of system permits a soft or easy landing, even in the absence of a lunar atmosphere, and is the kind of system that will have to be used to place a man or men safely on the moon. It is complex and heavy. The research problems involved are common to other apsects of space flight--viz; light-weight structures, stabilization and control, guidance, throttleable rockets, et cetera.

Because of the complexity of the soft-landing system, we seek simpler ways to land instrument packages on the moon. Instruments can be made rugged enough to withstand impact accelerations higher than those suitable for man. Consequently, we can consider systems that land at rather high speeds, and therefore, do not require all of the guidance, control and fuel required in a soft-landing system. These simpler systems do however require means for absorbing the shock of impact.

Some of the means available for absorbing the impact that are now being investigated are indicated on the chart. They are crushable structure, penetration spikes and pneumatic cushions. Of course, in studying these systems, we must at the moment assume that the hardness of the Lunar surface is comparable to that of the earth's surface. We are, however, developing techniques for measuring the hardness of the Lunar surface, so that when we send a rocket to the moon we will be able to obtain the desired information. Meanwhile, studies of the energy absorbing schemes are proceeding.

The crushable-structure concept employs light-weight metal structures, such as this honeycomb sample. When it is placed between a heavy object and the surface of impact, it collapses, absorbs energy, and assumes the shape you see in this second piece.

The penetration spike is a very simple device, but it works only when the surface of the ground is neither too hard nor too soft. It absorbs energy by displacing and compressing the material into which it penetrates, just as a nail absorbs the energy of a hammer blow.

Both the crushable structure and spike concepts require proper orientation with respect to the impacted surface. The gas cushion does not have this limitation. It is therefore, the simplest of all systems although requiring more research to understand how to design it. In the case of the gas cushion, the instrument package is suspended in the center by numerous radial cords. The system falls freely in the Lunar gravity field because there is no atmosphere. Upon impact the cushion compresses until the instrument package is brought to rest on the impacted surface. At this instant, the bag is split to avoid rebound. Energy is absorbed by compression of the gas, by shock waves generated in the gas, and by distortion of the bag skin. Gas cushions suitable for landing instrument packages on the moon might range between 5 and 25 feet or more in diameter, depending on the orbital height and the size and weight of the instrument package.

Because of the attractive simplicity of the gas cushion, it is undergoing extensive theoretical and experimental investigation in our Research Centers. The next chart shows how its efficiency compares with that of the soft-landing retro-rocket system. Here, the efficiency of the gas cushion relative to the retro-rocket system is shown plotted against payload weight. By payload we now mean only the instrument package carried by either landing system. In both cases the necessary auxiliary control and guidance systems have been taken into account. As can be seen, the gas cushion is superior to the soft-landing retro-rocket system at the smaller pay-load weights especially in the very small sizes. At the higher pay-load weights, the choice between the two systems becomes small and the retro-rocket becomes superior. Even so, the gas cushion might still be used because of its greater simplicity and reliability.

Before we are ready for a manned mission to the moon we shall, of course, be sending unmanned spacecraft there. Here is a model of one of them that is currently under development by the Jet Propulsion Laboratory. This spacecraft will weigh about 700 pounds and is intended to be launched by the Atlas Agena-B. The two folding vanes are solar energy collectors. The dish-type antenna transmits and receives signals to and from the earth. The main body of this spacecraft contains attitude control and navigation equipment, instruments, radio et cetera. At the top is a capsule that will be separated from the spacecraft proper and landed safely on the moon.

The next chart shows the sequence of events. During the early phases of the flight, injection and mid-course guidance are exerted. As the spacecraft approaches the moon, the small capsule is separated from the main spacecraft and retro-rockets are fired to slow the speed of the capsule. The main spacecraft crashes and is destroyed. The small capsule finally lands on the moon, its impact energy is absorbed by penetration spikes and it goes into operation obtaining data and transmitting them by radio back to earth.

For soft landings on the moon we must wait for the larger rockets such as Centaur and Saturn. Soft-landing systems for both of these vehicles are under study.

RE-ENTRY

The final phase of a manned Lunar circumnavigation mission is return to earth, re-entry into the earth's atmosphere and landing. The space-flight problems on the return trip are no different from those on the outbound trip, with the possible exception that navigational accuracy is more critical. The problem of re-entry is, however, peculiar to this phase and is a very serious one. As you know by now, there are two basic schemes for accomplishing re-entry; (1) the ballistic method with a non-lifting capsule, and (2) the winged or lifting method.

Both of these methods have advantages and disadvantages. The ballistic capsule is simpler and is therefore suitable for a first step such as Project Mercury. It has the disadvantage, however, of imposing very high g loads when re-entering at higher-than-earth orbiting speeds; it also lacks operational flexibility and requires a large landing area and an extensive retrieval operation. For these reasons, lifting capsule and winged re-entry vehicles are under study.

The lifting vehicle, which overcomes the disadvantages of the ballistic capsule, is more complex and is subject to higher heat loads and temperatures. Here is a photograph of a lifting vehicle structure under test at our Langley Research Center. The next chart gives an idea of where we stand today with respect to our ability to develop and build winged re-entry vehicles. This current ability has been made possible by our past research investigations, such as that indicated by the photograph shown a moment ago.

The chart shows temperature in $^{\circ}F$ plotted against a time scale of calendar years. The upper curve labelled "Re-entry Temperature" shows, by its downward trend, how the state of the art in aerodynamics, as related to the heating problem, has improved over the past few years. It represents the structural temperatures that would have been obtained during re-entry at satellite speed with the best aerodynamic configurations we knew how to build at the different periods of time. With the X-15 configuration in 1955, for example, the temperature of the structure during re-entry at satellite speed would have been 5500°F. As time and research progressed, we learned how to reduce the heat load, and therefore, the structural temperatures, by changes in the aerodynamic configuration. Sharply swept-back arrow-shaped wings, blunt leading edges and operation at high angles of attack were the key aerodynamic features resulting in the reduced temperatures indicated on the chart.

In a similar way, the lower curve shows by its rising trend how the state of the art in structures and materials has improved. This curve represents the temperatures that could be withstood by structures that we could have built at each period of time. The X-15 structure, which we knew how to build in 1955, can withstand a temperature somewhat greater than 1000°F. Obviously, the wide gap between the two curves in 1955 indicates that we were not ready then to build winged vehicles for re-entry at satellite speed. The X-15 is not that fast.

A short time ago the two curves came together, so that now the development of a winged or lifting vehicle for re-entry from satellite speeds is just barely possible. We have in essence a crude "solution" which makes possible the construction of a flight research type of vehicle such as Dyna Soar or the lifting capsule mentioned earlier by Mr. Low.

Our Lunar mission will require considerably more research, as the curves on this next chart indicate. Re-entry from a Lunar mission is made at substantially greater than satellite speed and the heat loads are, therefore, much higher. Unfortunately, it does not appear at present that the reduction in heat input resulting from improvements in aerodynamic shape will continue at the same rate as in the past. We must, therefore, look primarily to improvements in structure and materials to solve this problem at some indefinite time in the future.

Some progress is being made in this area, for example, with molybdenum. Molybdenum has a high melting point and is attractive for high-temperature structural applications, provided that we can weld it or otherwise fabricate it and also keep it from burning up at the high flight temperatures. This requires application of heat and oxidation-resistant coatings compatible with the underlying molybdenum. Although some progress has been made here, the final solution has not yet been achieved.

This chart shows two structural "sandwich" specimens made of molybdenum sheet and coated with a commercially available product. The fact that these specimens were made at all indicates that progress has been made in learning how to fabricate the material. The specimen on the left has not been tested. The one on the right has been subjected to a temperature of $2700^{\circ}$ F in air. Note that on this heated sample the coating has remained intact except near the welds.

## CONCLUSION

To conclude, I have tried to show you something of our advanced spacecraft research and technology and its meaning. This activity covers a wide variety of problems relating to launch and exit, space flight, Lunar and planetary exploration and re-entry into the earth's atmosphere. Current developments are pushing the present state of the art, but we are confident that our research activity will point the way toward safe, reliable and relatively economical space-flight.

NASA Release No. 60-118.

Statement of Dr. Abe Silverstein,
Director of Space Flight Programs, NASA
before House Committee on Science and Astronautics

Mr. Chairman and Members of the Committee:

In testimony before Congress a year ago, the NASA made a detailed technical presentation of the scope of its proposed space program. At that time we had only existed as an agency for a few months. Much of our discussion, therefore, dealt with future rather than current programs.

We have now had over a year of operating experience. In this period we have made an aggressive start on the space program that we described last year. We have already achieved certain scientific goals. We have clarified other areas so that we can now plan our experiments with greater certainty. In the light of our experience we have been able to sharpen, and in some cases redefine our objectives.

I should like to take this opportunity to review our space flight attempts and accomplishments during the past year and to indicate to you our plans for the next several years.

During calendar year 1959, the NASA attempted 16 major vehicle launchings for various missions in the space program. This chart lists these launchings in chronological order. We had, as you can see from the listings in grey, our share of unsuccessful launchings. This, we feel, is to be expected at the present state of the rocket vehicle art. We have in each case been able to determine the probable cause of failure and have taken corrective action in subsequent flights. The ratio of successes to failures has increased as the year progressed, and we have every cause to expect our future flight schedule to show an increasing percentage of successful flights.

Let me review each of our launchings for you.

On February 17, a Vanguard rocket placed a satellite into an elliptical orbit. The launch was completely successful. The instrumentation worked as planned and the data transmitters operated longer than was anticipated. The satellite contained two photocells to measure cloud cover over the earth. A wobble occurred in the satellite spinning motion during the launch, however, so that interpretation of the data has, thus far, been difficult. Analysis is still underway.

On March 3, a Juno II vehicle launched a conical 13.4-pound payload past the moon and into a virtually perpetual orbit around the sun. The payload, known as Pioneer IV, yielded excellent radiation data during the more than 82 hours that it was tracked to a distance of 407,000 miles from the Earth. It now courses through space as a new satellite of the sun.

In the next four months we had no successful launches. Two consecutive Vanguard launchings failed. On April 13, there was a failure during second stage separation. This caused the second stage to tumble and led to an impact of the payload only a few hundred miles off Cape Canaveral. On June 22, a regulator on a helium pressurization line failed. This flight also terminated only a few hundred miles from launch as a result.

On July 16, a Juno II vehicle had to be destroyed only 5-1/2 seconds after launch when there was a failure in the guidance power supply. This was the same type of vehicle that performed so well in the Pioneer IV shot.

The Thor-Able vehicle successfully launched the Explorer VI satellite on August 7. This payload weighed 142 pounds and was placed in a highly elliptical orbit extending to more than 26,000 miles from the Earth. This was the most complex payload yet launched by the United States. Fourteen scientific and technological experiments were conducted in this one mission.

On August 14, we experienced another failure with a Juno II vehicle. The payload, a 12-foot diameter inflatable sphere designed to measure air density at extreme altitudes, was plunged into the mid-Atlantic after launch when the attitude control system for the upper stages malfunctioned.

A week later, our first test firing of the Little Joe rocket in support of Project Mercury was aborted when the escape rocket on the capsule mock-up fired 30 minutes before scheduled booster launching. The Little Joe booster rocket itself was left undamaged. on the pad. The separation rocket malfunction was traced to a wiring error.

On September 9, a very successful firing was made for the Mercury program when an Atlas booster, known as "Big Joe", launched a "boilerplate" Mercury capsule into a ballistic trajectory downrange from Cape Canaveral. Although there was some malfunctioning of the booster, thereby exposing the capsule to more severe re-entry dynamic conditions than had been planned, the capsule came through with flying colors. So successful was the experiment, in fact, that a second, similar test was eliminated from the Mercury program.

On September 18, the last Vanguard rocket, with an alternate third stage solid rocket motor, placed a 50-pound scientific payload into an elliptical orbit. Much valuable scientific information was obtained from the multiple instrumentation. This launching was the third successful launching with the Vanguard vehicle.

We were scheduled to make yet another launching during September. An Atlas-Able vehicle was to place a payload in orbit around the moon, but during a static firing of the booster on September 24, the booster was destroyed by a fire and explosion.

On October 4, the Little Joe booster system for Project Mercury was successfully tested. In this test the rocket was topped by a dummy non-separating capsule and escape tower. The launching and flight were completely successful in producing the desired information on the integrity of the booster system, including the launcher and the destruct system.

On October 13, a Juno II vehicle made another successful launching of a satellite known as Explorer VII. This payload, weighing 91.5 pounds contained five separate scientific experiments and was a duplicate of the payload that failed to go into orbit during the August 14 launching. The transmitters are powered by solar cells and are still in good active working order. The transmitters will be shut off after a year of operation, although the satellite is expected to remain aloft for at least 20 years.

A second, successful Little Joe firing was accomplished on November 4. It was our objective in this test to evaluate the escape system during a simulated abort at maximum dynamic pressure conditions. The separation of the capsule and recovery was excellent. The capsule was recovered by a Navy fleet tug about 45 minutes after launch. A post-test evaluation indicated that the escape rocket ignition was delayed a few seconds, so that dynamic pressure at separation had fallen from the anticipated value. Thus, the test, although successful in all other respects, was not as severe as desired. A later successful test was, therefore, made on January 21 to re-evaluate this critical point.

On November 26 we suffered a disappointment when a second Atlas-Able lunar orbiter failed during the launch phase. There was no booster difficulty on this flight. Rather it was determined that the fiber-glass shield around the payload came off during an early phase of the flight. This led to premature payload separation from the vehicle.

We ended the year with a third successful Little Joe firing on December 4. On this test we planned a simulated abort, or separation of the capsule, at 100,000 ft. altitude. This was completely successful. The capsule coasted to 278,000 ft. before re-entering the atmosphere. It impacted about 177 nautical miles from the launch point at Wallops Island, Virginia, and was recovered within 1-1/2 hours by a Navy destroyer that was about 25 miles from the impact point. As you probably all know, the capsule contained a biopack with a monkey enclosed. The monkey was in excellent condition upon recovery and still remains so.

The NASA flight record during 1959 shows that we now have underway the start of a sizeable, significant space program. You will observe that during the first six months of the year we attempted only four launchings, and only two of these were successful. During the last half of the year we increased our tempo to twelve firings, and seven of these were successful.

I should also like to point out that in addition to the major vehicle launchings shown here, we made seven sounding rocket scientific flights in the last half of 1959, and a number of sounding rocket development flights.

The pace that we have established will accelerate in the near future. This chart summarizes our planned schedule of earth satellite firings for the next several years. I should like to point out that only major vehicle flights are shown here. The scientific missions will be supplemented by a sounding rocket program that will rise to and level off at a rate of about 100 to 120 firings per year. This will be about the level established during the IGY by the United States.

During the next year we will complete that part of our scientific satellite program that uses the Juno II launch vehicle. The payloads will all contribute to a further understanding of the energetic particle distributions and of the ionosphere.

The Scout vehicle will also become available during 1960. The initial firings will be primarily concerned with verification of vehicle performance, and hence will carry minimum scientific payloads. As the vehicle development is proven it will become an increasingly important part of our science program. It will eventually be used in this time period for a number of scientific satellites as well as near-space probe missions.

The Delta vehicle will also become available in the near future. A subsequent witness will present technical performance data on all these vehicles. Suffice it to say at this point that the Delta will give us a satellite capability several times larger than any we have flown to date.

In FY 1962 we expect to add Agena vehicles to our stable of boosters. The greater capabilities of these vehicles now under development for Air Force programs will enable us to incorporate improved instrumentation, both in type and in sensitivity, into our scientific program to give us an increasing insight into the scientific phenomena that are the objectives of this phase of our overall program.

The number of phenomena that we are concerned with is large. Consequently the number and variety of scientific payloads must assume the proportions you see here if we are to obtain a comprehensive understanding of that part of space fairly near the earth. We will, in these flights, variously measure atmospheric and ionospheric properties, energetic particle distributions, and magnetic and gravitational field distributions. We already know that some of these phenomena are variable and are affected by a number of external factors such as the earth's latitude, seasonal changes, solar activity, and so forth.

To evaluate all these factors it will be necessary to launch our vehicles along various flight paths. Some will be vertical probes to several thousand miles. Some will fly in nearly circular orbits several hundred miles above the earth; others will be launched on highly eccentric orbits extending as much as 100,000 miles from the earth at apogee. Some will fly at low angles to the equator, others will be launched in polar paths.

The very nature of the instruments that we fly, further adds to the picture. Certain instruments must operate in a non-magnetic field and hence cannot be combined with some others that must be made of magnetic materials. Some instruments designed to measure certain phenomena would be saturated and rendered inoperable by very high particle strengths -- these cannot be flown in the highly elliptical orbits that pass through the great radiation belt.

When we consider all of these factors and consolidate our findings, we arrive at a scientific satellite program such as shown in the chart.

All of our earth satellites will not be making purely scientific measurements of the properties of space about the earth. We shall also be launching a smaller number of satellites in the next several years to directly utilize space for man's benefit. This spring we shall launch our first payload specifically designed for the acquisition of meteorological data. Known as Tiros, this satellite will be launched by a Thor-Able vehicle.

A second version of the same payload, with additional sensing equipment, will be launched in early FY 1961 using a Delta vehicle. By 1962 it will be possible to launch a more advanced meteorological satellite known as Nimbus. This will contain more instrumentation than Tiros and will be stabilized so that the sensors will point at the earth throughout the flight path.

Before the end of this fiscal year we will also launch the first of our passive communication experiments known as Project Echo. The very thin aluminum coated Mylar 100-foot sphere will be used to reflect radio signals from one ground transmitting station to other ground receiving stations. We expect to make a number of such launches to develop the techniques and technologies in this area. We have already made two non-orbital launchings of the spheres from Wallops Island, Virginia, to evaluate such technical considerations as its separation and inflation.

I should like to caution you that neither the meteorological nor communications experiments in the next several years should be considered as an early approach to an operational system. These are experiments aimed at furthering the science and technology in these areas. Operational systems will come later and only after the problems have been identified and solved.

In addition to our flights near the earth, we will be engaged in a vigorous lunar and deep space program in the next several years. The Thor-Able vehicle will shortly be used to launch a probe into space to great distances from the earth. This probe should extend inward toward the sun as far as the orbital path of Venus. A number of scientific measurements will be made in the sweep-out path. One of the primary objectives will be an evaluation of long-distance data communication techniques.

We shall use a Delta vehicle to launch a very sensitive magnetometer and a plasma probe in toward the sun. In addition to scientific information on the properties of space, this experiment will serve as a developmental test of the new magnetometer that will be incorporated in many later spacecraft.

You will recall that we had two failures in our lunar orbiter program in CY 1959. We plan to make further attempts to launch similar payloads during FY 1961. Late that fiscal year the Atlas-Agena B vehicle will give us sufficient capacity to make experiments involving close-up TV pictures of the moon and the placing of scientific instruments on the moon's surface in working order. This will be a gradually built-up program, starting with technological development flights of the vehicle and spacecraft.

The Earth and the nearby planets, Venus and Mars, attain favorable positions in FY 1963 relative to the earth for space missions. The Centaur vehicle, having increased payload capacity because of the use of a hydrogen upper stage, will be used to launch payloads to the vicinity of these planets at that time.

Our Project Mercury program will continue at the fastest pace possible for such a complex research and development program. In 1960 we will have additional Little Joe flights to evaluate and qualify components. We had the first of these about a week ago.

It was highly successful. We will begin longer range Redstone flights in a few months. These Redstone vehicles will also be used to evaluate and qualify components and, at an appropriate time, will introduce man to the experiences of short duration space flight. I would emphasize that these Redstone flights will not be orbital but will subject the pilot to the launch and re-entry dynamics of flight as well as giving a period of weightless flight experience.

Further Atlas flights will be made in the time periods indicated. Some of these will be for technical qualifications of capsule components and for further operational and recovery training. This vehicle will also place man into orbital flight in space around the earth. I would hope to anticipate your obvious question of when man will make this first orbital flight by simply stating that it will occur at the earliest date that we feel there has been a satisfactory demonstration of the reliability of every element in the whole program.

Among the elements of the program that must be functioning perfectly is our tracking and data acquisition system. Western Electric Company has been given a prime contract to install the necessary system at a number of places throughout the world. There will be 18 Mercury Stations including some ships and a [illegible] control center at Cape Canaveral. This network is being developed using maximum possible equipment and sites already developed by the Military Services.

Not only is this tracking net expansion necessary in the conduct of Project Mercury, but other tracking facilities are being expanded or modified as necessary for the conduct of our whole space flight program. A later witness will discuss in some detail the various technical requirements that dictate the need for different data acquisition nets for different missions. Work is underway or has been completed for all of these stations such as our minitrack network, the optical tracking net, and the deep space net for tracking our lunar and planetary probes.

We at the NASA believe that the space flight program I have outlined is a sound, vigorous program for the exploration of space. We recognize and do not minimize the limitations that are placed on us by the launching vehicle capabilities now available to us. As more advanced vehicles become available we are increasing and will continue to increase the scope and depth of the space program to the greatest extent possible.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

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Statement by

Dr. T. Keith Glennan, Administrator

National Aeronautics and Space Administration

before the

Sub-committee on Deficiency Appropriations

House Committee on Appropriations

February 1, 1960

Mr. Chairman and members of the committee:

I want to thank you for this opportunity to present NASA's request for a $23,000,000 supplemental to the Fiscal Year 1960 budget of $500,575,000.

May I take this opportunity to say that I have enjoyed the cordial relationship that has developed between our agency and the members of the Appropriations Committee during the 15 months of NASA's operational existence. The extensive experience of the Chairman, Mr. Thomas, in dealing with the research and development activities of a number of the Independent Agencies has made his advice particularly valuable to us.

With me today are members of our administrative and technical staffs who are prepared with item-by-item details of the supplemental request for funds submitted by NASA. After the supplemental request presentations, I would like to have enough

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time to discuss with the sub-committee a matter relating to the staffing of our agency.

I want to assure the sub-committee that NASA has made a very real effort to live within its $500,575,000 budgetary limit. However, space exploration involves a highly dynamic, rapidly changing and expensive technology now in the very early pioneering stages of development. This supplemental request covers, for the most part, needs resulting from technological developments in Project Mercury, the first phase of the Nation's manned space flight program.

It is my belief, based on discussions with responsible members of our staff, that inability to fund necessary modifications during fiscal year 1960 will result in a serious slowdown of this project which has had the Nation's highest priority -- a DX rating -- since April 1959. It would be no exaggeration to say that the immediate focus of the United States space program is upon this project.

Of the $23,000,000 requested, $19,000,000 is urgently needed for Project Mercury. The balance of the request -- $4,000,000 -- is for modifications to a launch pad at the Atlantic Missile Range to accommodate the Atlas-Agena B and other advanced launch vehicles. The supplemental breaks down as follows:

...$12,200,000 under Research and Development for Project Mercury.

...$10,800,000 under Construction and Equipment, of which $6,800,000 is for the Mercury tracking and data-collection network, and $4,000,000 is for the launch pad modifications.

NASA's fiscal year 1960 budget provides a total of $74,962,000 for Project Mercury. During calendar year 1960, the major part of the Mercury pre-flight and flight development program will be completed; component qualification and astronaut training flights will have been initiated.

During calendar year 1961, the Mercury qualification programs will be completed and the tracking network will become operational. If we do not experience delays or major developmental setbacks, it is our aim to place a man in orbit during calendar year 1961.

If NASA is to meet its Mercury deadlines, we must have an additional $12,200,000 in Research and Development to cover improvements in the Mercury capsule's design, construction, and instrumentation. The need for these modifications has arisen as the result of NASA's rigorous developmental tests and continuing analysis of safety requirements.

Let me give you some examples of what I mean. The original capsule had two hatches, one in the top and one on the side. The side hatch was bolted. We are now making it possible for the side hatch to be triggered from the inside by the pilot, much as a canopy is blown from a jet fighter plane.

It would be used only in emergencies. We are also re-designing the instrument panel to make fuller utilization of the pilot's capabilities, and installing a large window, in place of a small porthole, to increase visibility for the pilot. This window also allows him to see the horizon during the retrorocket firing period, hence aiding him to navigate. We are adding an inflatable impact bag to ease landing shock.

The supplemental also covers the following improvements:

...Instrumentation to provide a more powerful communications system for the pilot.

...An alternate reaction control jet system which may prove more efficient than the present system and be substituted therefor.

...Six additional Mercury capsules, bringing the total to 20. These are being procured because our tests and analyses have shown that it is more economical to buy new capsules than to rebuild them after test flights.

...A "rate-damping" installation in the manual control system to cut down on capsule oscillation and make the pilot's job easier when he chooses to use the manual controls.

...Considerable additional flight monitoring and telemetry equipment for the Mercury installation at the Atlantic Missile Range. This equipment is vitally needed for the manned Redstone flights this year.

Modifications of this nature are bound to arise in such top priority, compressed-schedule projects wherein research, development, design and fabrication must go forward simultaneously. The same situation holds, to some extent, for the tracking and data-collection network item.

The most recent review of Mercury network construction progress revealed the need for additional funds if the network is to become operational on schedule. The $6,800,000 request will provide the following:

...Supplemental instrumentation and facilities at the 16 Mercury stations, including the Mercury control center at the Atlantic Missile Range.

...Facilities at the U.S. Navy's Pacific Missile Range, Point Arguello, California, and its Kauai Island installation in Hawaii. These two installations will become part of the 16-station network in place of two Air Force installations which, it now appears, must be kept free for the Defense Department's Discoverer program.

Recent studies have shown that a decision to abort the Mercury mission must be made at AMR within a shorter time span than had been previously estimated if the capsule is to come down on the Atlantic Ocean as desired, and not land in Africa. This situation places greater dependence on the Mercury installation at AMR requiring considerably more equipment.

Finally, the launching pad which will undergo modification at AMR is Pad 12, now being used by the Air Force for Atlas firings. To accommodate the Atlas-Agena B, which is scheduled for initial launchings in late spring or early summer of 1961, considerable ground support equipment must be provided. Also needed are a new umbilical tower tall enough to service the extended rocket vehicle, and a repositioning of the working platform to suit the Agena B's particular needs.

The Atlas-Agena B and the Atlas-based Centaur are vital to the Nation's space program in the coming years. The Atlas-Agena B, for example, will be capable of launching a spacecraft of several thousand pounds on a 300-mile orbit or a spacecraft of several hundred pounds on a lunar trajectory.

Before requesting my associates to explain the program changes in more detail, let me stress again my belief that the proposed supplemental for fiscal year 1960 is vital to the urgent prosecution of the U.S. space program. As the members of this committee know, NASA is almost wholly a research and development operation, with all the uncertainties and unforeseen problems that such an operation entails. Our program requires constant review and re-evaluation.

Again, Gentlemen, I express to you my appreciation for this opportunity to discuss our program and to present the supplemental request.

# # #

NASA Release No. 60-121

February 3, 1960

Statement of Albert F. Siepert
Director of Business Administration, NASA
RELATING TO THE TRANSFER OF THE
ABMA DEVELOPMENT OPERATIONS DIVISION TO NASA

I appreciate this opportunity to discuss the plan transmitted to Congress by the President on January 14 relating to the transfer to the National Aeronautics and Space Administration of the Development Operations Division of the Army Ballistic Missile Agency (ABMA) and certain other Department of Defense functions. Immediately after the President's decision was announced on October 21, 1959, our Administrator, Dr. Glennan, designated me as NASA's principal negotiator to arrange with the Army the details of the transfer. Since that time, this has been essentially a full-time assignment in order to assure that the transfer of the von Braun group to the NASA is effected without disrupting the essential space and weapons projects now under way. NASA at this point is confident that the plans are realistic and that, with the support of this Committee and the Congress, the proposed transfer can be accomplished in a manner which will greatly strengthen this nation's space efforts, both civilian and military. There are several aspects of the proposed plan which, I believe, will be of special significance to this Committee.

1. Relationship of Transfer to the National Space Effort

Under the National Aeronautics and Space Act of 1958, NASA was established as a civilian agency to plan and conduct space exploration for peaceful purposes. This mandate is accompanied by an "except" clause which reserves to the Department of Defense ". . .activities peculiar to, or primarily associated with the development of weapons systems, military operations, or the defense of the United States. . ."

This "except" clause has caused apparent misunderstanding among the public as to who is responsible for what in the space field. The intent of the law has been to give NASA, on the one hand, sole responsibility for developing and carrying out the national space exploration program, in <u>all</u> its aspects. On the other hand, the Defense Department is responsible for defending the nation in every medium or environment at its disposal -- on land, on sea, in the air and in space. If the Armed services fire a missile into space, it is for the development of a defense mission; it is not firing the shot as part of the national space exploration program. Such activities by Defense are governed strictly by their advancement of military objectives. Understandably, of course, these Defense missions may advance the state of the space art.

It was in this context that the President reviewed the requirements and current activities of the Department of Defense and NASA, and decided on October 21, 1959, to assign NASA sole responsibility for development of very high-thrust vehicles required for space exploration. This decision was based on the consideration, concurred in by the Secretary of Defense, that presently there is no current clear-cut military requirement for these space vehicles. On the other hand, future exploration of space, manned and unmanned, for scientific and peaceful purposes, can only be achieved through use of vehicles of very high thrust.

In line with this assignment of responsibility, NASA and DOD worked out an agreement that NASA assume technical direction of the Saturn vehicle systems. As you have heard from Dr. von Braun, this is an interim management arrangement until the Development Operations Division can be transferred to NASA in accordance with the plan now before you. As you know, this project was initiated and funded by the Advanced Research Projects Agency of DOD; it was being carried forward by ABMA. The Saturn vehicle now constitutes a substantial and growing part of the Development Operations Division's workload; the military or weapon systems assignments of this group are rapidly decreasing. Accordingly, the President has proposed that the unique capabilities and interests of this Division in space flight development should be transferred and made available to NASA.

Needs may well develop in the future for the use of large launch vehicles for defense purposes. To prepare for this possibility, the President has instructed NASA to be responsive fully to specific DOD requests in this area. Furthermore, NASA and DOD will continue with a coordinated program for development of space vehicles based on current IRBM and ICBM missiles and growth versions of those missiles.

The background for these arrangements is covered in more detail in the Memorandum to the President which Dr. Glennan and Secretary Gates jointly submitted on October 21, 1959. If the Committee wishes, I shall be happy to supply a copy of this document for the record at this point.

In summary then, the decision of the President to assign to NASA sole responsibility for the development of space launch vehicles, and the corrolary action to transfer the Development Operations Division to NASA serves to clarify the responsibility of NASA and to allocate to it certain available resources in a manner to facilitate NASA's discharge of these responsibilities.

2. Development and Growth of NASA's Space Capabilities

The transfer of the Von Braun group will give NASA a unique and demonstrated competence in space vehicle development. Where this capability fits into the NASA space picture can best be explained by reviewing quickly the brief organizational history of NASA.

NASA became officially operative on October 1, 1958. As you know, the new agency absorbed the 43-year old National Advisory Committee for Aeronautics, together with its aeronautical and space research missions. However, NASA's over-all mission is far broader than that of NACA, since it is empowered to direct all U. S. aeronautical and space research and development, apart from military projects. (In aeronautics, NASA limits itself to research and it cooperates closely with DOD in aero-space problems.) Thus, NASA was provided an immediate competence in various fields of aeronautical and space research. While NACA's laboratories initially had been developed to perform work in the field of aeronautics, much basic research in the new fields of space was already under way. Research projects included studies relating to re-entry, development and testing of sounding rockets, studies relating to aerodynamic characteristics of missiles, propulsion research, and similar fundamental work of importance in the space field. What was lacking, however, was adequate competence in the design, construction, and operation of space vehicles and in the related fields of advanced guidance and control, communications, tracking, and data reduction.

The need for expansion of the NASA capability in the space field was recognized by the Congress in the enactment of the Space Act of 1958. Under Section 302 of this Act, the President was empowered to, ". . .transfer to the Administration any functions (including powers, duties, activities, facilities, and parts of functions) of any other department or agency of the United States, or of any officer or organizational entity thereof, which relate primarily to the functions, powers, and duties of the Administration as prescribed by Section 203 of this Act." Acting under this authority, the President, on November 28, 1958, transferred to NASA personnel, equipment and functions formerly assigned to the Navy's Project Vanguard. In addition, certain personnel from the Upper Atmosphere Group of the Naval Research Laboratory were also transferred to NASA. From this group, NASA was fortunate in acquiring some 400 highly trained and experienced personnel in the fields of space sciences and satellite applications, as well as tracking, communications, and data reduction.

On December 3, 1958, the Jet Propulsion Laboratory, operated under contract by the California Institute of Technology, was transferred from the Department of the Army to NASA. JPL personnel, therefore, contribute to NASA a demonstrated ability in virtually all aspects of space science and technology with particular capacity in development of upper stages and guidance systems, and tracking for deep space probes.

Neither the Vanguard or JPL groups, however, provided NASA with the necessary capability to develop big space vehicle systems. The Huntsville group clearly gives NASA a team of outstanding experts who are capable not only of "in-house" research and development of large launch vehicles, but also of providing, as needed, the responsible technical monitoring and direction of the various industrial contractors who assist in the engineering and production of such launch vehicles.

3. Impact of Transfer on the NASA Organizational Structure

The transfer of the Huntsville facility and its integration into NASA organizational structure has been helped considerably by some adjustments and redefinition of the previous mission assignments within NASA. Our Headquarters organizational structure has already been modified to permit improvement of NASA's program development and execution. The Headquarters organization of NASA now provides for four (rather than three) major operational elements. Instead of a single Office of Space Flight Development, in its place we have established two groups:

(1) The Office of Space Flight Programs, under the leadership of Dr. Abe Silverstein, will be primarily responsible for the conduct of space exploration including manned space flight represented today by Project Mercury; the conduct of scientific investigations of space; the development of practical applications of space technology including communications and meteorological satellite systems; and the development of necessary tracking, communications and data reduction systems. The Goddard Space Flight Center, the Jet Propulsion Laboratory and the Wallops (Virginia) Station will report to this office.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D.C.

NASA RELEASE NO. 60-122
DU 2-6325

For Release a.m.
Monday February 15, 1960

CANADIAN GROUP AND NASA TO CONDUCT SATELLITE STUDY OF IONOSPHERE IN 1961

The National Aeronautics and Space Administration has announced that the first arrangements have been concluded for a joint satellite project in NASA's program of international cooperation in space sciences. The project will be conducted by the Defence Research Telecommunications Establishment of Canada and the NASA to study the ionosphere by means of a sweep frequency topside sounder satellite. The cooperative Canadian-U.S. experiment is scheduled for 1961.

The Defence Research Board (DRB) is the scientific element of the Canadian Department of National Defence, and the Defence Research Telecommunications Establishment (DRTE) is one of its research agencies.

According to the arrangements, the DRTE will provide the satellite and its instrumentation and will operate a network of receiving stations within Canada for recovering telemetered data. NASA is to provide high altitude sounding rockets and launching services to test the Canadian satellite prototype instrumentation, the satellite launching vehicle, and launching facilities. NASA will be responsible for ground-based telemetry and recording apparatus outside Canada to recover telemetered data for at least one year, and will furnish copies of satellite data recorded outside Canada for exchange with Canada.

The sweep frequency topside sounder experiment is expected to enhance greatly our knowledge of the characteristics of the upper levels of the ionosphere (electrically charged regions of the upper atmosphere). Existing ground stations are able to obtain information by reflecting radio waves from the bottom side of the ionosphere, i.e., up to about 200 miles, at approximately 140 locations throughout the world. Soundings obtained with the Canadian-U.S. experiment will extend the ground station data to altitudes of about 700 miles and in addition, will furnish information for geographical areas which are not covered by the present ground station network.

In operation, the Canadian sweep frequency sounder will send out radio signals whose frequency will sweep through a range of 2 to 15 mc to obtain information on the characteristics of the upper ionosphere at different frequencies.

The satellite will be launched into a polar orbit, and principal studies to be made will concern the ionosphere over Canada, the United States and South America. Soundings in the auroral zones will be of particular interest to Canada in respect to special communications problems in high latitudes and arctic regions.

- END -

# NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

HOLD FOR RELEASE UNTIL:
8 p.m. Monday,
February 15, 1960

Address by T. Keith Glennan

Administrator

National Aeronautics and Space Administration

Worcester Economic Club

Worcester, Massachusetts, February 15, 1960

Mr. Chairman, Members of the Worcester Economic Club, Ladies and Gentlemen:

My presence here tonight is the result of two forces, one pulling -- and the other pushing me toward the same end objective. When Arthur Bronwell starts on a project, he sees it through, as I suspect many of you have found to be the case when he has asked you for money for your great community and national asset -- the Worcester Polytechnic Institute. He started on the job of planning this trip and speech for me many months ago, even though I was loath to comment myself so far in advance. On the other hand, being acutely conscious of the fact that I head an agency of the government engaged in spending a very large number of taxpayers' dollars every year, I feel an obligation to report in person to groups of interested citizens whenever my schedule will permit. With Bronwell pulling and my conscience pushing, I am here tonight to discuss with you some of the important facets of the Nation's program in space exploration.

It is particularly appropriate that we are discussing these matters in Worcester. Much of the pioneering work in rocketry was done in this community by the late Dr. Robert H. Goddard. Born in Worcester in 1882, Goddard earned his bachelor's degree at Worcester Polytechnic Institute in 1908, completing his work for both a Master's and a Doctor's degree at Clark University a few years later.

Dr. Goddard began thinking about the development of rockets in 1909 and received two U. S. patents in 1914. Supported in his research by grants from the Smithsonian Institution, Clark University and Worcester Polytechnic Institute, he was able to launch, in 1926, the first liquid fueled rocket -- some five years before the Germans began the work which led to the V-2 rockets of World War II. Known today as the father of American rocketry, Goddard, a quiet man, a meticulous scientist and able teacher, long a member of your community, left behind him at his death in 1945, the basic seeds from which have sprung our present day billion dollar program.

Let me start my discussion by defining several of the terms we use in the missile and space businesses -- terms which are confusing to you if you are like most of the people with whom I talk. In fact, I want, if I can, to differentiate for you these two related but distinctly different activities. Then I will tell you something about our program in space exploration. I will describe briefly the inter-relationships of NASA with the Department of Defense. Touching briefly on the resources available or to be available to us, I will finish with a statement of the reasons for our interest as a nation in a dynamic, costly, and exciting program of space research and exploration.

First--as to definitions. One of the most common mistakes made by the layman--and, indeed, by persons who have some considerable knowledge of our operations--is that of confusing the missile business with the space business. To an extent, such confusion is natural--for these two activities are related. But to confuse them as some people do and as the Soviet propagandist would like us to confuse them is something to be avoided. Let me explain.

The missile and space businesses are related because they both use rockets as propulsion units--oftentimes the same or very similar rockets. They both use launching pads--usually the same launching pads at Cape Canaveral or at the Pacific Missile Range. The same or similar techniques are used to provide guidance and control information to the rocket units in flight. They are or can be tracked in their research and development flights by the same ground-based equipment. And a man experienced in the design, production, testing, and launching of a rocket to be used as the propulsion unit for a nuclear warhead would likewise be qualified to perform these same functions on a rocket which was to form one unit of a launch vehicle system for use in the space exploration program. In fact, most of the large rockets used in our space program were developed originally for use as warhead carriers in the military missile program.

Here the similarity stops. I think I can demonstrate my point by using some models I brought along with me.

Now to the real importance of avoiding confusion in thinking of missiles on the one hand and launch vehicles for space activities on the other. The Russians have developed much more powerful rockets than we have thus far developed. They began development at a time--five or six years before we undertook seriously to build a missile-carrying rocket--when the Russian nuclear warheads were very large, heavy, and relatively inefficient. The early versions of our atomic bombs were heavy and large also, but we concentrated on the manned bombers--the B-29, B-47, and the B-52 -- as the basis for delivery of our nuclear warheads. Only after we had solved the problems of producing lighter, smaller, and enormously more efficient atomic and hydrogen bombs did we start a determined, all-out program to produce a rocket to carry these bombs to the target. This was in late 1954 and early 1955. And in a little more than half the time taken by the Russians, our scientists, engineers, and industrial contractors have produced the Thor and Jupiter IRBM's and the Atlas ICBM as operationally useful missiles capable of carrying to the target, with the required accuracy, warheads as powerful and destructive as may be required.

Thus it should be clear, I hope, that our less powerful rockets when used as missiles are just as effective in achieving their purpose as are the larger, more powerful rockets of the Soviet Union. As a matter of fact, it is probable that their rockets are more powerful then they now need for military weapons purposes. When used as the base booster in a space launch vehicle system, however, the story is different. In this case, the Russians, using their more powerful rockets as elements in a launch vehicle,can loft into a satellite orbit or propel into deep space to the moon and beyond much heavier instrumented payloads than we can. In addition, they have the weight-carrying capacity to transport highly precise guidance, control, and communications units that have made possible the extraordinary and technologically difficult feats which have characterized their program. Until we develop more powerful launch vehicle systems, we cannot exactly duplicate these Soviet achievements in space. But our inability to do this in space has nothing to do with the effectiveness or accuracy of our missiles.

Just last week in Havana, Anastas Mikoyan was quoted by the New York Times as saying, "Those who threaten war, now know that we have sent a rocket to the moon and that we can send it with the same precision to any part of the world." This seems to me a reasonable statement. But the fact that we have not sent a spacecraft to the moon has nothing at all to do with the capability or accuracy of our own warhead-carrying missile systems. There is no reason, I can assure you, for you or anyone else to translate the Russians' successes in space into a superiority in missile accuracy or reliability or effectiveness. While somewhat involved, I do hope this explanation, which started out to be merely a definition of terms, has given you a better understanding of the differences and the similarities in the missile and space businesses.

Now let me turn to a discussion of the Nation's program in space exploration. And because this is a political year, I think it desirable to state my strongly held opinion that the Nation's space program is not and should not be the subject of partisan politics. The rockets that launch our satellites do not bear the insignia of the Republican Party or that of the Democratic Party. They do not carry the name of one of the military services or the name of my agency -- the National Aeronautics and Space Administration. They carry only these words -- United States. They represent the genius and labor, and the devoted efforts of the citizens of this nation, regardless of religion, color, or political affiliation. They represent the tax dollars of all the people -- your dollars and mine.

I assert then, that the Nation's program of space exploration is, and by its very nature should be, the responsible concern of all of our people. It is in this spirit that I have come here tonight to report to you as stockholders in this venture -- perhaps I should say -- adventure. For certainly the years ahead give promise of being years of excitement and achievement in areas of human effort which until very recently have been accepted as fit subjects only for the comic books and the less responsible of the Sunday supplements.

It is pertinent, in discussing this program to look at the "Declaration of Policy and Purpose" set forth in the National Aeronautics and Space Act of 1958 which guides our activities. There, the Congress declared: first, "that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind," and, second, "that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities." The Act then established a civilian agency, the National Aeronautics and Space Administration, to be given responsibility for all of the

Nation's space activities except -- and I quote -- "activities peculiar to or primarily associated with the development of weapons systems, military operation, or the defense of the United States." These latter remain the responsibility of the Department of Defense.

The creation of "a civilian agency exercising control over aeronautical and space activities sponsored by the United States" with the one exception noted in the Act was a legislative act having the most profound implication: henceforth it was to be clearly understood that it was national policy to emphasize activities in space for peaceful purposes of benefit to all mankind -- for civilian, rather than military, purposes.

The Act then directs that NASA shall "plan, direct, and conduct aeronautical and space activities," and it proceeds to give this term "aeronautical and space activities" a three-part definition. These are, first, "research into, and the solution of, problems of flight within and outside the earth's atmosphere"; second, "the development, construction, testing, and operation for research purposes of aeronautical and space vehicles"; and third, "such other activities as may be required for the exploration of space."

The first two, research into problems of flight and the development and operation of aeronautical and space vehicles for research purposes, are certainly not new, nor are they unique to NASA. The National Advisory Committee for Aeronautics, our principal predecessor organization, and the armed services were deeply engaged in such activities for years before NASA was established. But the third of these, "such other activities as may be required for the exploration of space," projects us into an entirely new dimension of human activity. The exploration of space! For the first time in the long history of legislation these words have been written into a law. It is safe to predict that the world will never be quite the same again.

The exploration of space, then, is NASA's specific mission, and it is a mission for which it is solely and exclusively responsible under the law. This is a mission just as unique to NASA as the military defense of the Nation is to the armed services. And, in the largest sense of the term "security," it is a mission of vital importance to the security interests of the United States. All of this should be kept in mind as I discuss program activities very briefly.

The element in our program about which you have heard most frequently is Project Mercury. This project has as its objectives the placing of a man into an orbital flight around the earth at a height approximating 120 miles; his safe recovery after the completion of three orbits lasting over a period of approximately four and one half hours; and the acquisition of data showing something about his ability to perform useful work while traveling through space in a weightless condition. This is a mind-stretching, arm-stretching effort -- one that gives meaning to all the other elements in our program. For Mercury is but the first limited but significant step toward our long-range goal -- manned flight to the moon and the nearby planets.

I am sure there are those among you who wonder about -- perhaps even question -- the amount of effort and the large sums of money involved in Project Mercury, which is being carried out under a priority equal to that of our military missile programs. The best answer I can give is that it is the nature of man to want to explore the unknown. Interplanetary space will be explored one day. It seems to be within reach now, so we are making the effort. But let me quote briefly from a discussion of this matter by an eminent physician the other day. He had this to say, in part:

"These studies (refering broadly to studies of various phenomena in space) will not be complete until the scientist himself is able to make meticulous investigations on the spot. This is true, not only for the biological, but, also, for many other physical, chemical and geological problems which are involved. Although significant engineering achievements in automation, sensing, recording, programming and telemetering have been realized and considerable future development is in prospect, the indispensability of the human observer in much of space exploration is well established. Man's versatility and selectivity, his ability to preceive the significance of unexpected and unprogrammed findings or to react intelligently to unanticipated situations have not been simulated by any combination of physical devices, however complex, which have been developed or are even contemplated. Human intelligence and manual skill in servicing the complicated mechanisms of space vehicles or repairing breakdowns in flight are not readily dispensed with or replaced. When along with these attributes are considered his weight of 70 kg., his total resting power requirements of 100 watts, his ability to function for years without maintenance or breakdown, then even the most elaborate provisions for his sustenance, welfare and safety are amply justified simply in terms of engineering efficiency. A national program in space science which does not recognize the essentiality of the human observer and does not plan to utilize him most effectively may wait indefinitely for the automatic devices to replace him or be limited to incomplete and opportunistic observations."

I cannot take the time to describe in detail all of the other elements in our program -- we would be here all night. But I can summarize them by saying that we have planned and are carrying out a broadly based program of scientific experimentation in space which will involve, ultimately, the landing of self-propelled instruments on the moon, the detection and understanding of various phenomena to be encountered in interplanetary space, and the orbiting of optical and radio astronomy devices and of permanent space-based laboratories.

Meteorological and communications satellites have a part in our program. These are thought of as being of possible -- even probable -- economic importance in the forseeable future. Meteorological satellites should make possible weather observations over the entire globe. Today, only 20% of the globe is covered by any regular observational and reporting systems. If we can solve the problems of handling the vast amounts of data that will be received, develop methods for the timely analysis of the data and the notification of weather bureaus throughout the world, we should be able to improve by a significant amount the accuracy of weather predictions. I am told that an improvement of only 10% in accuracy could result in savings totaling hundreds of millions of dollars annually.

Similarly in communication, we find that within the next twenty years existing techniques are apt to be stretched beyond reasonable economic limits by the demands to be made for long distance communications. It is difficult to see how transatlantic television will be possible when one realizes that there is presently a capacity of less than 100 telephone channels across the Atlantic and a single television channel is equivalent in band width to 1,000 telephone channels. It appears that a system utilizing satellites is the most promising solution to this problem.

As you can well understand, one indispensable element in this program is the launch vehicle system -- the rockets that propel the spacecraft into outer space. As I have said earlier in this discussion, the Soviet Union has the ability to place substantially heavier payloads into orbit than we can at the present time. It is in this single area that they now have superiority in the space business. And that superiority makes it possible for them to undertake difficult, useful, and spectacular feats which are denied to us for the time being.

We have under way a very aggressive program to correct this situation -- not just to match the Soviet Union, but because we will need such a capability in our own program in the years ahead. Within the next twelve to eighteen months, we should begin launching rocket vehicle systems that will allow us to match and out-match what the Soviet Union has done to date. But it is not realistic to think they will not progress in the meantime -- in fact, we know now that they have been testing more powerful rockets which could be used in launch vehicle systems for space exploration. And so our highest priority projects include Saturn, which will permit us to place approximately fifteen tons -- 30,000 pounds -- in an orbit 300 miles above the surface of the earth.

Saturn is the project being carried out by Wernher von Braun and his group at the Huntsville, Alabama, center which is in the process of being transferred to NASA from the Army. The President has authorized a request for additional funds to accelerate this project.

Consequently, we are asking the Congress for 230 millions for Saturn for the 1961 fiscal year. Unfortunately, even under the accelerated program we are following, this capability of the Saturn class vehicles will not be in hand before 1964 at the earliest. It takes a long time to develop one of these beasts. It is probable that a two-stage Saturn vehicle of somewhat lesser capability will be available and useful in our program in late 1963.

Giving dates in these instances is a proper pastime for some -- but not for those of us who have the responsibility for making good on the promises given. I am confident, however, that Dr. von Braun, to whom we will give major responsibility for the bulk of our launching vehicles program -- I am confident that he and his associates will deliver on schedule if we give them the support and resources they will need.

Looking at the human resources available to us to carry out this broadly based program, I would point out that the Act directed that NASA absorb the 43-year-old National Advisory Committee for Aeronautics. This world-renouned research and development organization gave us a base of nearly 8,000 employees and three large, well-equipped laboratories and several supporting field stations. In rapid succession we acquired several hundred people from other governmental activities, principally military laboratories, began an active recruiting campaign, and had transferred to us by the Army the 2,400-man operation known as the Jet Propulsion Laboratory, managed by the California Institute of Technology under contract to NASA. Most recently, the President has reported to the Congress his intention to transfer to NASA from the Army Ballistic Missile Agency in Huntsville, Alabama, the Development Operations Division of that organization under the direction of Wernher von Braun. This latter group will include 5,500 scientists, engineers and support people.

Of particular interest to you here in Worcester is the 2,000 man laboratory we are building at Greenbelt, Maryland. Concentrating on the development of satellite space craft, it has been named the Goddard Space Flight Center -- a fitting recognition of the very great basic contributions to rocketry made by Dr. Goddard.

As of June 30, 1960, we will have a staff of slightly more than 18,000 -- the great bulk of these having been acquired by transfer from other agencies of government. In spite of the size of this organization, we estimate that approximately 75 per cent of our budget will be expended through contracts with industry, educational institutions, and other non-governmental groups.

Financial resources available to us are substantial. Our 1959 fiscal year budget totalled $335,000,000. In fiscal year 1960 -- the year ending 30 June 1960 -- the Congress voted for NASA the sum of 501 millions. Our request to the Congress for the next fiscal year totals $938,000,000, of which $23,000,000 has been requested, actually, as a supplement to the budget for the current year. These are not inconsiderable sums of money. And you should know that our long range planning suggests the expenditure of a total of 12 to 15 billion dollars for space exploration over the next ten years.

I said earlier that I would speak about the relationships between NASA and the Department of Defense. In doing this, let me try to clear up some of the confusion that exists concerning what is frequently referred to as the "Nation's Space Program". This program should more properly be termed the Nation's Space Exploration Program. It is a program--in terms of the law governing NASA's operations -- consisting of all activities designed to further the exploration of space. It is a program for which NASA is directly responsible. And it is a program which does not embrace the military uses of space, although the results of NASA's efforts and findings will be fully available to the Department of Defense.

For the Armed Services, space is properly not a program at all, but just another place where military functions can be performed for the defense of the Nation. The military utilization of space, and the research and development effort directed toward that end, are integral parts of the total defense program of the United States. Military space projects are undertaken only to meet military requirements, and they presumably must compete in the military budget with alternative, and more conventional, means of accomplishing the same military objectives. For the military, the test must be: Is it, all things considered, the most prudent way to expend our resources to achieve the best defense of the Nation? The military has no obligation whatsoever to perform any part of its mission in space merely because space is there and because man now, for the first time in history, finds it accessible.

NASA, on the other hand, has been directed by law to plan, direct, and conduct such activities as may be required for the exploration of space.

Actually, NASA and the Department of Defense have worked out over the past year a reasonable division of responsibilities. The space projects for which they have responsibility have been undertaken to meet military requirements. On projects in which we have a joint interest, we have excellent interchange. Our people sit together with theirs on technical requirements committees, although management authority is always clearly allocated to one or the other agency. We are supported in the Mercury Project by a very substantial military task force concerned with capsule recovery operations. In the X-15 program, we are jointly involved with the Air Force and the Navy. I think it safe to say that, as reasonable men and under the guidance of the President, we have established an effective division of effort with satisfactory cooperation all around.

Let me now finish this discussion with a statement of the reasons I believe this program of space exploration to be a useful and necessary activity of the Federal government. In the first place, there is a conviction held by most of us that research in space will turn up great amounts of new information that ultimately will be useful to man. The point is often made that man's progress to date has resulted from his search for knowledge and the application of that knowledge to his benefit in the eradication of oppressive conditions of labor, in the abolition of routine drudgery and in the elimination of hunger and disease. It appears probable that weather forecasting, communications, navigation and geodesy are fields that will benefit from the use of space as a base for operational systems. In most of these cases, it seems clear that only with satellite-based systems can real advances be made, and in some it appears that great contributions to the economy will result.

Second, we have man's known unwillingness to leave unconquered any new and adventurous frontier, and thus there is an urge that pushes us toward manned space flight. To me, success in this part of our venture will be peculiarly a part of the pioneering tradition that has made this a nation of individuals, free to risk their future as each may choose.

Third, there is this matter of competition with the Soviet Union. While space research is only one of the many areas of scientific, economic and political rivalry between our two great nations, it is the most exciting, difficult and glamourous of all. For decades, the world at large has regarded this country -- our own country -- as pre-eminent in most scientific, technological and industrial fields. They have known us by our works and judged them good.

The Soviets have managed to convince many, even in the relatively sophisticated western nations, and certainly in the less industrially developed nations, that Russian accomplishments in space-- and they are considerable -- are the true measure of scientific and technological advancement, and thus the measure of the strength of a society and a form of government.

Finally, we have the possibility of the discovery of life on the far-off planets. Such a discovery could very well become the crowning achievement in man's quest for knowledge in space -- an achievement that, historically speaking, could transcend any present considerations of competition with Russia or of near-future benefits from satellites and space probes.

Speaking more prosaically -- as I wrote these words I was reminded of a story told about Mark Twain. In a discussion with the pilot of a river boat at the time in our history when steam was beginning to replace sail, Twain answered the protests of the pilot against the new fangled invention by saying to him --"when its steamboat time, you steam".

This is the time for space research and space travel. It is a time of challenge and change. Let us remind ourselves of the words of Brutus spoken in Shakespeare's "Julius Caesar" -

"There is a tide in the affairs of men
which, taken at the flood, leads on to fortune;
Omitted, all the voyage of their life
Is bound in shallows and in miseries.
On such a full sea are we now afloat;
And we must take the current when it serves
Or lose our venture."

Ladies and gentlemen of Worcester, it has been a privilege for me to be here with you and to discuss this great adventure into the unknown. Thank you very much.

NASA Release No. 60-123

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

HOLD FOR RELEASE UNTIL:
12:00 noon, Tuesday
February 16, 1960

Statement by Arnold W. Frutkin

Director

Office of International Programs

before the

Members of the Inter-American Defense Board, Washington, D.C.

February 16, 1960

INTRODUCTION

It is a privilege to have been asked to speak to you today about the international programs of the National Aeronautics and Space Administration (NASA). This is particularly so because our country's first steps in space exploration, in both planning and execution, were taken in concert with other nations in the Americas. It was scientists from both North and South America, meeting in Rome in 1954, with their colleagues from Europe and Asia, who initiated the chain of events which have now extended man's reach beyond his immediate environment. There in Rome, at a meeting of the World Committee for the International Geophysical Year (IGY), it was agreed that the technology required to place scientific satellites in orbit was available and that the effort should be made. Later, the cooperation of governments and scientific communities in Latin America made it possible to establish the tracking and telemetry stations which were required to follow the first U. S. satellites. I will have more to say about these stations later. I should like now only to express again our thanks to our Latin American colleagues for the very valuable assistance which has been given to us in this work.

THE PHILOSPHY OF COOPERATION

One may well ask why it is that NASA, while heavily committed to a difficult and ambitious program of space research, nevertheless seeks to engage in cooperative efforts with other nations. My first remarks suggest at least two reasons:

-- First, man's first ventures into space were taken in the context of international cooperation in science -- as part of the program of the International Geophysical Year. The IGY operation captivated men's minds. It has achieved a dynamism which almost demands that we continue to work within the same sort of framework.

-- Second, the technology of operations in space research virtually requires global efforts. No country can be satisfied with tracking and telemetry efforts which are restricted to its own borders. Even the Soviet Union has requested the services of tracking stations located in your countries, in South Africa, and in Australia in order to cover the movements of its satellites over the Southern Hemisphere. Soviet scientists have also made important use of the great radio telescope at Jodrell Bank in England.

But there are other considerations.

-- We recognize that scientists in all countries can make important contributions to the theory and practice of space research.

-- Ultimately, more ambitious efforts to push our knowledge ever further into space will become so costly and complex that the burdens will be too great for any one nation to carry. It will be desirable to pool energies and contributions as well as costs.

-- Above all, perhaps, we know that space is inherently international in character. It is already a widely accepted principle that no one nation should appropriate to itself regions or natural bodies in space. There is strong feeling everywhere that we must not extend cold wars and armaments competitions into the vastness of space. We, for our part, hope to demonstrate by the openness of our program and our readiness to participate in cooperative projects, that we subscribe in fact as well as in word to these principles.

Each of the considerations which I have just mentioned was reviewed by the Congress of the United States when, in the Spring of 1958, it debated the establishment of a civilian space agency in the United States. The records of these Hearings show very clearly how conscious our legislators were of every one of these points. So, it is not surprising that the Congress wrote into the Act establishing NASA that one of its purposes should be "Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof..." NASA has accepted this objective not as a pious pronouncement but rather as a substantive obligation.

In order to provide for aggressive support of international objectives within NASA in response to the Congressional mandate, the

Administrator established the Office of International Programs. It is the function of this office to generate, to encourage, to coordinate, and to provide necessary supporting services for, NASA's cooperative activities. I should like now to tell you what principles we mean to follow in cooperative programs. Then I propose to tell you something about those programs in which we are already engaged.

We feel that programs of international cooperation should be substantive in character, contributing toward the technical and scientific objectives of space research. This suggests that the programs themselves should grow out of, or be capable of integration with, NASA's own operating and research programs. But we do not wish to suggest to other nations' scientists what projects or programs they should adopt, or, indeed, that they should enter into space research at all. If cooperation is desired, however, we are eager to discuss the possibilities. In such cases, we believe that consideration should be given to specific, limited projects, for it is too early in this new science to chart broad general programs. The essential criterion should be that the projects have scientific or technical validity. We would hope that proposals would represent experiments or other projects which we ourselves would wish to carry out if they were not to be done jointly.

Generally speaking, we cannot at this time consider programs which would involve an exchange of funds. Rather, each nation should be able to support its own contribution. However, it is not necessary that contributions be of equal scope and magnitude. Beyond these particular points, it goes without saying that the free exchange of information, and especially the results of our experiments, should be made available to the scientists of all nations. To this end we support the activity in the United Nations regarding the peaceful uses of outer space. Similarly we are, through our National Academy of Sciences, giving full support to the International Committee on Space Research (COSPAR), one of the permanent offshoots of the World Committee for IGY.

## TYPES OF PROGRAMS

I should like to tell you now of the types of international programs which NASA is already conducting. It is convenient to distinguish four basic types of international activity in which NASA is engaged:

(1) Operational -- This involves the acquisition and/or operation of tracking and telemetry stations and services as necessary to meet operating requirements for a global range.

(2) Informational -- This category includes the dissemination of advance information to foreign scientists so they may prepare to utilize U. S. space satellites in independent ground-based experiments of their own. It also includes the dissemination of results of experiments for the information and benefit of scientists everywhere.

(3) Joint -- This category includes projects, experiments and exchanges of mutual interest and advantage between U.S. and foreign scientists.

(4) Personnel Exchanges and Training -- This refers to programs which provide close working relationships for foreign scientists in NASA laboratories.

Let me describe each of these four types of programs in more detail.

Operational Programs. NASA's foreign operations indicate how widespread our international activities have already become. Coordinated space probe tracking activities are conducted or about to be conducted in a total of 19 countries. Based in our own hemisphere, these now extend to Africa, and the Pacific while additional stations are in prospect in the United Kingdom and Canada.

The backbone of these tracking activities are the radio and optical stations established in South America. (The optical stations, established by the Smithsonian Astrophysical Observatory, are operated now for NASA under grant.) In Chile, Equador and Peru, these stations are operated jointly with technicians of these countries. In every case, the governments concerned have generously entered into agreements for the continued operation of these stations.

Other Minitrack and Baker-Nunn Camera stations are operated in South Africa and Australia. Two new Minitrack stations--designed to extend our network latitudinally--are planned in Newfoundland and England, subject to the approval of the Canadian and British governments.

This basic operating network is supplemented in three instances by contract or grant arrangements. The largest steerable radio "dish" in the world, at Jodrell Bank in England, has contributed invaluable tracking services during the past year under contract with NASA. Grants for tracking and telemetry services, together with necessary U. S. equipment, have gone to the University of Heidelberg in West Germany and to the Radio Research Laboratories of the Ministry of Posts and Telecommunications in Japan.

At the present time, NASA is engaged in establishing a special network of tracking and data acquisition stations abroad in connection with Project Mercury, the first step in the U. S. manned satellite program, Government-to-Government negotiations are in progress for sites in Australia, Bermuda, the Canaries, Canton Island, Mexico, Nigeria, and Zanzibar. At least two of the Mercury stations will be operated by nationals of the host country. Additional participation will be possible to the extent that qualified personnel become available.

This special network is required because of the orbital inclination which the Mercury capsule is designed to take. Tracking and telemetry stations are more closely spaced for this program than for any other yet conducted by NASA. This will permit virtually continuous monitoring of the physiological reactions and condition of the Mercury astronaut. Necessary decisions may then be made at the earliest possible time in the interests of the astronaut's safety.

Finally, as our efforts turn increasingly toward deeper probing into the reaches of our planetary system, we will require specialized stations with high capabilities for very long range tracking. A network of radio telescopes for this purpose is being established.

We hope to supplement installations now within our own borders by locating new 85-foot steerable "dishes" for the tracking of deep space probes in the southern Pacific and in southern Africa, with the permission and participation of the governments concerned.

As I have said, 19 countries or political entities are involved in these network arrangements. It is clear, then, that NASA's global tracking range is truly international in character and that a very considerable input is provided by technicians and scientists abroad. In addition, the land for most of the station sites has been made available without cost.

These far-flung activities of NASA help to broaden scientific interest, participation, and contribution in the exploration of space. It is NASA's desire to encourage further participation by nationals of the countries in which tracking sites are located.

Informational Programs. NASA continues the launching announcements and data exchanges which were instituted during the International Geophysical Year. The launching of sounding rockets is reported in brief flight summaries which are filed with World Data Center A (Rockets and Satellites) at the National Academy of Sciences. The Academy then distributes this material to the other World Data Centers in England and the Soviet Union. At six-month intervals, the material is catalogued for the information of the scientific community.

Announcements of the launching of satellites and space probes are made routinely within a few hours through SPACEWARN, a special world communications net established during the IGY, as well as in the press.

These announcements provide scientists with orbital characteristics, satellite or probe weight, types of instrumentation and experimental objectives.

Results of experiments are published in the recognized scientific journals and distributed also through the World Data Centers. Techniques for interim cataloguing and periodic notification of available results are now under joint study by NASA and the National Academy of Sciences.

NASA is also participating extensively in scientific symposia, in many ways the life-stream of international scientific exchange. During 1960, NASA scientists and technicians have attended, or will attend and contribute to, meetings in Nice, Tokyo, Helsinki, Ottawa, Copenhagen, Madrid, Buenos Aires, and other cities abroad as well as here in the United States. Potentially the most significant of these symposia is the United Nations Space Conference. NASA is preparing to play a central role in organizing the U. S. contribution to this hopeful exchange among pioneers in space from all nations.

The methods, objectives, and standards of international exchange of data were reviewed by COSPAR last month in Nice. It is of some interest that this meeting resulted in renewing the understandings for scientific exchange which had been established during the IGY. In addition, these understandings were enlarged in at least two respects. The Soviet scientists have now agreed to provide the orbital elements of the trajectories of their satellites so that scientists everywhere can compute the appropriate look angles needed to locate these satellites by radio or optical means from any location on earth.

In the past, the Soviets provided this information only for specific locations on the globe. In addition, it has been agreed that launching nations will hereafter give advance notice of satellite launchings where the orbital inclination, the power output, the radio frequency to be used or the opportunities for observation are significantly different from those in past satellites.

NASA seeks not only to comply with but to go beyond the exchanges already agreed on internationally. Even before the COSPAR meeting, steps were taken to provide the world scientific community with an opportunity to participate in a future U. S. experiment in accordance with local capabilities and interests. The experiment is Project Echo, the launching of a 100-foot inflatable, aluminized sphere which will serve as a passive reflector for communications experiments and will also permit studies of atmospheric drag. The details of the experiment have been disseminated not only in the United States but also to COSPAR and individual scientists abroad who may be interested. With this advance information, foreign scientists may prepare the necessary equipment and arrange for such ground-based experiments as are feasible. This procedure will serve as a pattern for future advance notification where appropriate -- in the interests of broad participation, maximum utilization, and, not least, optimum benefits for all.

In the same way, NASA has notified the international scientific community that the telemetry calibrations for Explorer VII will soon be available to them to use for direct reduction of the data provided by that satellite.

Joint Projects. Perhaps the most interesting of the possibilities for international cooperation is participation by the scientists of two or more countries in the design of experiments and in the preparation of payloads for rockets, satellites, and space probes. NASA has already taken a number of significant steps in this direction. Within a very few months of its establishment, NASA was engaged in preliminary technical discussions with representatives of the Canadian Defence Research Board on a proposed joint project to sound the ionosphere from above. The Canadians will also provide the antenna and satellite shell required. Meanwhile, NASA will develop a fixed-frequency sounder. Both will be placed in orbit by the United States. Tracking installations will be modified to acquire data from both, and a coordinated ground-based net will simultaneously probe the ionosphere from below. The British have expressed interest in this phase of the project. Thus, a multilateral experiment is already in preparation and will be conducted sometime in 1961.

In March 1959, NASA authorized the National Academy of Sciences' delegate to COSPAR to offer, on behalf of the United States, to place in orbit individual experiments or complete satellite payloads prepared by scientists of other nations. Because the closest possible collaboration is desirable in such efforts, it was stated that the experimenters were welcome to work together with American teams in the development of their projects.

In July, the United Kingdom sent a team to the U. S. under Professor H. W. S. Massey to discuss a British proposal within the framework of NASA's offer to COSPAR. It was tentatively agreed that British scientists, over a two-to four-year period, would instrument perhaps three satellites for launching, probably by means of NASA's Scout vehicle. Each nation assumes responsibility for its own contribution. Specific proposals for four experiments to be flown in the first joint satellite were agreed upon last month. They will involve studies of solar radiation, electron density and temperature, and cosmic radiation. These will permit unique correlations of the on-board experiments themselves as well as between these and ground-based or air-space experiments. An exchange of notes at the governmental level will formalize this arrangement. The proposed experiments were communicated to COSPAR in January and have been endorsed by that Committee.

The U. S. offer to COSPAR in March 1959, was followed up during September and October 1959 by discussions abroad with scientists of a number of European countries. These discussions were undertaken by Dr. Hugh Dryden, the Deputy Administrator of NASA, in company with Dr. Homer Newell, the Deputy Director of the Office of Space Flight Programs, and myself. The discussions were directed toward those countries which were known to have established, or to be considering establishment of, national space centers or committees. We wanted to learn something of the development of space interests abroad and to offer, without any suggestion of interference, to discuss cooperative programs if, and when, the space interests in each country became organized and endorsed by their governments or major scientific institutions. We described (1) the organization of space activity in the United States; (2) NASA's special interest in international cooperation in accordance with the National Aeronautics and Space Act of 1958; (3) the progress already made in programs of cooperation; and (4) the kind of cooperation we thought desirable. We said also that cooperative programs might ultimately be formulated at the diplomatic level, if required by reason of magnitude or content, but that in all cases technical discussions on an informal basis should precede governmental agreement. Quite frankly we feel this is necessary to ensure that cooperative programs are technical in character and that any commitments are acceptable to our operating people. Finally, it was proposed that COSPAR be informed of the nature of any agreed scientific programs, so we might benefit from the interest, constructive comment, and auspices of the international scientific community.

The organization of space interests is almost everywhere in early stages. Nevertheless, in addition to the United Kingdom and Canada, Australia, Belgium, France, Japan, Italy, and Sweden are known to have established national space committees. (The U. S. S. R., of course, has had a space commission in existence for some years.) While definitive programs have not yet been announced, and informal discussions suggest that relatively limited programs are in view, there appears to be a strong interest in cooperative programs in the European and Pacific nations. In fact, only cooperation will make possible programs extending beyond relatively limited sounding rocket projects. This is due, in large part, to the very substantial financial requirements involved in more ambitious efforts.

In any event, it is becoming increasingly evident that the NASA offer to COSPAR has generated considerable discussion abroad, with the result that interest in cooperative programs has been expressed formally or informally on behalf of scientists in Argentina, Australia, Belgium, France, Japan, Israel, Italy, New Zealand, Sweden, the United Kingdom, and West Germany. The interest has been both formal and informal and ranges from requests for sounding rockets or the exchange of scientific personnel to full-scale preparation of instrumented satellites.

For example, the Australians have proposed that they prepare instrumentation to study very low frequency emissions above the ionosphere in the regions of the lines of magnetic force. The instrumentation would be launched in rockets or satellites by the United States. There is in prospect also a "multi-lateral" rocket sounding program. The U. S. hopes to purchase British Skylark rockets for which the Australian launching range at Woomera is fitted and to instrument them for the necessary experiments, the rockets themselves to be launched by the Australians. NASA has expressed interest in every case and has invited specific proposals where these have not been provided. NASA considers, therefore, that a very wide range of cooperative activities is in prospect and it is the Administration's intention to encourage these most energetically.

NASA has not confined its interests in cooperation in space research to the West. The possibilities of cooperation with the U.S.S.R. have been explored as opportunity presented. An extensive discussion of preliminary nature was conducted in mid-November with the Chairman of the Soviet Commission for Inter-Planetary Travel, Professor Sedov, and another member of the Commission, Academician Blagonravov, during the visit of the U.S.S.R. delegation to the American Rocket Society Meeting here in Washington. The Soviet scientists then expressed willingness to consider some form of cooperation in space activity but stated their belief that such cooperation would have to proceed "step-by-step". The only step which they were at that time willing to discuss was the Space Conference under U. N. auspices which had been proposed by their representative in the United Nations. More recently, the NASA Administrator, Dr. T. Keith Glennan, in an address before the Institute of World Affairs in Pasadena on December 7, 1959, offered the services of the Project Mercury tracking network to the Soviet Union when, as, and if it should conduct a man-in-space program. Dr. Glennan then stated that data could be acquired and transmitted in its raw state to the Academy of Sciences in Moscow. He stated also NASA's readiness to utilize Soviet equipment should special recording or data readout be required. The offer was promptly transmitted though the National Academy of Sciences to the Soviet Academy of Sciences. While no response has yet been received, NASA plans to continue exploration of possibilities for cooperation with the Soviet Union in projects of mutual interest as occasion permits.

Personnel Exchanges and Training. In order to provide an opportunity for foreign scientists to develop their interests and capabilities for space research, NASA has established postdoctoral and senior resident research associateships, administered by the National Academy of Sciences. These associateships provide stipends beginning at $8,000 per year. While not intended primarily for foreign nationals, thus far five scientists have been accepted for such associateships from abroad. The countries from which they come include Japan, India, New Zealand and Denmark.

NASA's preferred method of operation in connection with joint projects, as well as specific proposals by foreign space committees, will operate to increase the number of foreign scientists working in U. S. space laboratories. Of course, considerations of operating efficiency in the building of our own teams requires that discretion be used in accommodating training and fellowship personnel. At present NASA does not have funds, outside of the associateship program, to make available for the travel and subsistence of scientists. Where, however, their own governments or scientific institutions provide such funds, NASA will make every effort to provide the laboratory support and guidance possible.

## SUMMARY

NASA's operational requirements and statutory obligations involve it in a wide range of international activities and programs. These are already generating wide interest and promise to increase participation by foreign scientists in the investigation of Earth's spatial environment and the regions beyond. NASA continues to support the constructive exchange practices of the IGY. Beyond this it has taken a number of positive steps to develop concrete programs of international cooperation. These steps have met with gratifying response and a program of still uncertain yet clearly significant magnitude appears assured. The program includes data and information exchange, operational assistance, ground-based participation, technical training, and finally joint projects in space exploration. Elements of the program are already in being. The remainder is rapidly taking shape, though the fruits of any efforts in this most demanding of disciplines will be realized only after long and difficult application.

We hope very much that our Latin-American colleagues will consider useful projects of joint interest to expand our existing collaboration in space research.

NASA Release No. 60-124

## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

FOR RELEASE UPON PRESENTATION:
Expected about 2 p.m., February 18, 1960

Statement of T. Keith Glennan
Administrator
before the
NASA Authorization Sub-committee of the
Senate Committee on Aeronautical and Space Sciences
Relating to the Transfer of the
ABMA Development Operations Division to NASA

I welcome this opportunity to discuss briefly the President's plan, transmitted January 14 to the Congress, relating to the transfer to the National Aeronautics and Space Administration of the Development Operations Division of the Army Ballistic Missile Agency (ABMA) at Huntsville, Alabama, and certain other Department of Defense functions.

Authority for the President's action is contained in Section 302 of the National Aeronautics and Space Act of 1958. Paragraph (c) of that section provides, however, that: "After December 31, 1958, no transfer shall be made under this section until (1) a full and complete report concerning the nature and effect of such proposed transfer has been transmitted by the President to the Congress, and (2) the first period of 60 calendar days of regular session of the Congress has expired without the adoption by the Congress of a concurrent resolution stating that the Congress does not favor such transfer."

Respecting the transfer of the Huntsville group from the Army to NASA, unless the Congress by concurrent resolution adopted by March 14 or thereabouts, says that it opposes the transfer, it will take place.

It is my further understanding that the prime reason underlying the proposal contained in HJ. Resolution 567, titled "To effect immediately the Transfer of the Development Operations Division of the ABMA to the NASA," was to provide for the means whereby the Congress would be taking affirmative action, rather than merely passive action, in this transfer matter.

Hardly less important is the boost in morale of the highly trained Huntsville personnel that will result from such action. These able people have, understandably, been uncertain about the future. Passage of the Joint Resolution will clear the air.

The following comments are in support of both the transfer plan itself and the above-mentioned Joint Resolution.

The Space Act established NASA as a civilian agency to plan and conduct space exploration for peaceful purposes, reserving to the Department of Defense in an "except" clause..."activities peculiar to, or primarily associated with the development of weapons systems, military operations, or the defense of the United States." The intent of the law has been to give NASA, on the one hand, sole responsibility for developing and carrying out the national space exploration program, in all its aspects. On the other hand, the Defense Department continues to be responsible for defending the United States in every medium or environment best suited for that defense--on land, on and beneath the oceans, in the air... and now in space. But, as vital as this kind of activity in space by the Armed Services certainly is, it should not be mistakenly considered as part of the national space exploration program. This latter--space exploration---is NASA's responsibility as a matter of law.

As we look to the future, NASA's responsiblities will call, most certainly, for very powerful launch vehicles. At present, there is no clear military requirement for rocket boosters of the 1 to 1.5 million pound class. These considerations led to the decision of the President, in October 1959, to give to NASA full responsibility for the development of high thrust rockets and the launch vehicle systems that would use these rockets. This decision, concurred in by the Secretary of Defense, meant that the responsibility for Saturn was moved to NASA, first through our taking over technical direction of this space launch vehicle system, and now, through the President's plan to transfer the von Braun team at Huntsville.

Parenthetically, I should note that needs may well develop in the future for the use of large launch vehicles of the Saturn class, or even larger, for defense purposes. To prepare for such a possibility, the President has instructed NASA to be fully responsive to specific Defense requests in this area. And, of course, Defense and NASA will continue with a coordinated program for development of space vehicles which use current IRBM and ICBM rocket engines and growth versions of those missile systems.

Many times, I have noted that there are three ingredients essential to NASA's accomplishment of its responsibilities as stated in the Space Act: - (1) A program designed to achieve the end objective of manned flight into space whenever and wherever desired; (2) an organization of men and women of specialized talent who are highly motivated and dedicated to the concept of exploration into the unknown, and (3) the funds necessary to the urgent prosecution of the program. It is the second of these three ingredients...the organization of specialized talents...that we are considering here today.

We at NASA were given a huge head start in this business of organizing the team to do the space job assigned us by the inheritance of nearly 8,000 scientists, engineers, and supporting personnel from the National Advisory Committee for Aeronautics. Thus, we were provided with first rate research facilities being used to carry out significant research programs on a broad front in both aeronautics and space. More important, we acquired experienced and talented people who believe, very earnestly, in what we are trying to do, and who feel the urgency with which we must do our work.

There were, however, research, development and operational areas in which the old NACA team was not working and in which NASA had to become deeply involved to accomplish its total mission. These included electronics, guidance, launch vehicle systems, etc.

There were two ways we could proceed. One would have been to start from scratch, selecting sites, building and equipping new facilities, and then undertaking the painful process of staffing the new laboratories. This course would have been very expensive; it would have meant raiding the personnel of other organizations; most seriously, it would have meant long delays in getting ahead with our job.

The other avenue--the one we chose--was to integrate into a single hard-hitting organization, the facilities we already had with others doing outstanding work in the areas where we needed competence. In this manner, we secured the talents of the Jet Propulsion Laboratory at Pasadena, Calif., which is operated by the California Institute of Technology. Similarly, we gained the high order of competence represented by the 300 or so people who had been working on the Vanguard and other projects under Navy direction.

But we continued to need a highly imaginative and competent engineering and design group, capable of serving as an integral part of the NASA organization in the planning and executing of both short and long-range programs in the development of launch vehicle systems. We wanted such a group also to monitor contracts with other governmental agencies and with industry, and to provide necessary ground testing and assembly capability...and finally, to supervise space vehicle launching operations for NASA.

The requirements we sought to satisfy are possessed by the von Braun group at Huntsville.

With the transfer to NASA of responsibility for development of the large-thrust launch vehicle systems...including Saturn which von Braun's group is working on...and with the completion of work on certain military projects, Defense and Army agreed last October on the desirability of the transfer to NASA of this group and the facilities it is using.

The transfer will be accomplished without interruption of the vital work on Saturn now in progress. As a matter of fact, the detail arrangements are being worked out between Army and NASA in a spirit of complete harmony and cooperation. Since the technical direction of the Saturn program was assigned to NASA, the project has been given the highest national priority, the upper stage configuration has been agreed upon, work is being accelerated with increased overtime wherever needed, and a substantially larger budget for FY 1961 has been requested by the President.

At the end of the present fiscal year...again assuming Congressional approval for this transfer, the National Aeronautics and Space Administration will have organized into one government agency what I am confident will stand as an outstanding collection of scientific, technical and supporting personnel. With the continued support of the Administration and the Congress, NASA will carry out...purposefully, vigorously and with a sense of dedication, the space exploration program of the United States.

With confidence we will meet any competitive challenge in the area of space that this Nation faces today, or that it may face in the future.

No. 60-127

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

Remember Australian agreement on Mercury stations. See Release File

**WASHINGTON 25, D. C.**

NASA RELEASE NO. 60-132
DUdley 2-6325

For Release 6 p.m.
Friday February 19, 1960

NASA-JAPANESE SCIENTISTS HOLD PRELIMINARY DISCUSSIONS
FOR COOPERATIVE SPACE RESEARCH EXPERIMENTS

The National Aeronautics and Space Administration today announced that informal preliminary technical discussions have been held with scientists of Japan to explore the possibilities for cooperative experiments in space research.

Dr H. Itokawa, Professor at the University of Tokyo Institute of Industrial Science, Dr. Y. Aono, Vice Director, Radio Research Laboratories, Ministry of Posts and Telecommunications, and Dr. T. Inoue, Research Officer of the Planning Bureau, Science and Technics Agency, spent the past week here at the invitation of the National Aeronautics and Space Administration. The invitation followed an expression of interest on the part of Japan in participation with the United States in cooperative scientific space programs, an interest welcomed and reciprocated by the United States.

During their visit the Japanese scientists met with representatives of the Goddard Space Flight Center and toured the Langley Research Center and Wallops Station, Va. Among the representatives of NASA Headquarters with whom the Japanese met were Dr. Hugh L. Dryden, Deputy Administrator of NASA; Dr. Abe Silverstein, Director, Office of Space Flight Programs; Dr. Homer E. Newell, Deputy Director, Office of Space Flight Programs; and Mr. Arnold W. Frutkin, Director, Office of International Programs.

Further meetings with the Japanese are anticipated after Drs. Itokawa, Aono, and Inoue return to Japan for consultation with other Japanese scientists and governmental authorities.

This meeting of NASA and the Japanese scientists is a result of an offer NASA made to all world scientists in 1959 at a meeting of the International Committee on Space Research (COSPAR). As part of its program of international cooperation in space science, NASA offered to conduct with other nations, space research experiments which would be of mutual interest.

- END -

# NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

Release No. 60-130
Du. 2-7807

For Release:
Monday AM's
February 22, 1960

DECEMBER CONTRACTS

During December, 1959 the National Aeronautics and Space Administration wrote contracts or transferred funds to other contract-supporting government agencies for the following projects:

Rensselaer Polytechnic Institute (Rensselaer, New York) -- $46,000 -- Investigate plasma properties of a variety of gases over a wide range of pressures, electron energies and degrees of ionization by microwave techniques.

Colorado Seminary (University of Denver, Colo.) -- $119,000 -- Investigate ionization phenomena in hydrogen, nitrogen and oxygen, using high velocity molecular beams.

Office of Naval Research (Navy) -- $110,000 -- NASA funding for a joint project involving ONR, National Science Foundation and NASA to provide a balloon-borne observatory. A television camera would be mounted on a telescope to look at stars from an altitude of about 20 miles. Princeton University is providing project management support.

Air Research and Development Command (Air Force) -- $19 million -- Initial NASA funding on a $43 million contract with Convair Astronautics for airframe, stage integration and upper stage tanks of Centaur. ARDC is supplying technical support.

Strickland Bros. (Portsmouth, Va.) -- $92,000 -- Construct terminal facility for Back River substation at NASA's Langley Research Center, Hampton, Va.

Hajoca Corp. (Williamsport, Pa.) -- $78,000 -- New gate and isolation valves for 9 by 6-foot wind tunnel at Langley.

Minstein Construction Co. (Albertson, N. Y.) -- $120,000 -- Two masonry buildings, one to serve as cable terminal and the other to house radio communications equipment and rocket destruct controls at NASA's Wallops Station, Va.

Carpenter Contruction Co., Inc. (Norfolk, Va.) -- $310,000 -- Construct mainland terminal building and a mainland telemetry receiving building at Wallops.

Harron, Rickard & McCone Co. (San Francisco) -- $25,000 -- Machinery for machining metals by electro-disk charge method at NASA's Ames Research Center, San Francisco, Calif.

Research, Inc. (Hopkins, Minn.) -- $31,000 -- Infrared heating equipment for 3.5-foot hypersonic wind tunnel for model testing at high temperatures for Ames.

Lumm Corp. (Toledo, Ohio) -- $41,000 -- Install propellant piping systems for propulsion test chambers at NASA's Lewis Research Center, Cleveland, Ohio.

Jarrell-Ash Co. (Newtonville, Mass.) -- $33,500 -- Spectrograph to be used to find impurities in metals in basic materials research at Lewis.

Ampex Corp. (Birmingham, Mich.) -- $47,500 -- Magnetic tape recording system to be used in virtually all of Lewis' research facilities.

Harrisburg Steel Co. (Harrisburg, Pa.) -- $117,000 -- Gas transport tanks for Lewis.

O. G. Kelley Co. (Boston, Mass.) -- $40,000 -- Fabricate and assemble various reactor components for NASA's Plumbrook Nuclear Reactor Facility near Sandusky, Ohio.

Bowshot, Cooper & O'Donnell Engineers (Cleveland) -- $70,000 -- Engineering design and drafting servies for rocket systems research facility at Lewis.

Leib-Jackson, Inc. ( Columbus, Ohio) -- $66,000 -- Installation of piping, controls and structural iron for Plumbrook facilities.

Didion Bros. (Sandusky, Ohio) -- $29,000 -- Restoration of a building which is to become the Plumbrook administration building.

Electronic Associates, Inc. (Long Branch, N. J.) -- $252,000 -- Analog computer system to be used in data reduction work in the X-15 research plane program at NASA's Flight Research Center, Edwards, Calif.

White Diesel Engineering Division (Springfield, Ohio) -- $120,000 -- Two large diesel generator sets for central power plant at NASA's Goddard Space Flight Center, Greenbelt, Md.

Panoramic Radio Products, Inc. (Mount Vernon, N. Y.) -- $42,000 -- Indicators, calibrators, and analysis.
equipment required to speed the evaluation of early Redstone-boosted Mercury Capsule launches.

Tenney Engineering, Inc. (Union, N. J.) -- $80,000 -- One simulated altitude test facility at Atlantic Missile Range to test barometric switches, environmental and life support systems of the Mercury capsule prior to launch.

McDonnell Aircraft Corp. (St Louis, Mo.) -- $33.6 million -- Funding to cover contract changes in Mercury capsule design and lay-out, additional capsules and support equipment.

Naval Weapons Plant (Washington, D. C.) -- $60,000 -- Engineering design and drafting services for various projects at Goddard.

END

# NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

Statement by

Dr. T. Keith Glennan, Administrator

National Aeronautics and Space Administration

before the

Senate Committee on Appropriations

February 23, 1960

Mr. Chairman and members of the Committee:

I appreciate having this opportunity to present to you NASA's request for a supplemental appropriation for Fiscal Year 1960 in the amount of $23,000,000. You will recall that the Fiscal Year 1960 appropriation was approved late last summer in the amount of $500,575,000.

With me today are members of our senior staff who can answer, in any detail you may desire, your questions on the need for and use we will make of these funds. My purpose will be to sketch briefly the situation which makes necessary this request.

I would assure you that NASA has made a diligent effort to live within the budgetary limitations approved by the first session of the 86th Congress. It must be clear to you, however, that space exploration involves a highly dynamic, rapidly changing and very expensive technology which is in its very early and pioneering stages of development.

Powerful external forces are pressing this nation in a competition for high stakes in many fields of scientific, technological, economic and political activity. Of these, space exploration and research is the most novel, the most visible and the one in which the apparent lead of the Soviet Union lends itself most readily to impressive and effective propaganda techniques. Our answer has been to develop our own well-planned, sensibly balanced program of research and development and to prosecute that program with a sense of very real urgency. This supplemental request is presented as a result of our attempts urgently to meet the needs of that program in two areas.

Of the $23,000,000 requested, $19,000,000 is needed for Project Mercury and $4,000,000 for modifications to a launch pad at Cape Canaveral to accommodate advanced types of launch vehicles to become available to us late in the current calendar year. You will recall that Project Mercury is this Nation's first attempt to launch a man into an orbit about the earth and to recover him safely. It is my belief, based on discussions with responsible members of our staff, that inability to fund necessary modifications during Fiscal Year 1960 will result in a serious slowdown of this project which has had the Nation's highest priority -- a DX rating -- since April 1959. It would be no exaggeration to say that the immediate focus of the United States space program is upon this project.

The supplemental request breaks down as follows:

...$12,200,000 under Research and Development for Project Mercury.

...$10,800,000 under Construction and Equipment, of which $6,800,000 is for the Mercury tracking and data-collection network, and $4,000,000 is for the launch pad modifications.

NASA's Fiscal Year 1960 budget provides a total of $74,962,000 for Project Mercury. During calendar year 1960, the major part of the Mercury pre-flight and flight development program will be completed; component qualification and astronaut training flights will have been initiated.

During calendar year 1961, the Mercury qualification programs will be completed and the tracking network will become operational. If we do not experience delays or major developmental setbacks, it is our aim to place a man in orbit during calendar year 1961.

If NASA is to meet its Mercury deadlines, we must have an additional $12,200,000 in Research and Development to cover improvements in the Mercury capsule's design, construction, and instrumentation. The need for these modifications has arisen as the result of NASA's rigorous developmental tests and continuing analysis of safety requirements. One of my associates will be happy to give you more detailed information on the nature of the changes that have been found necessary to insure the integrity of this project. Let me say simply that modifications of this nature are bound to arise in such top priority, compressed-schedule projects wherein research, development, design and fabrication must go forward simultaneously. The same situation holds, to some extent, for the tracking and data-collection network item.

The most recent review of Mercury network construction progress revealed the need for additional funds if the network is to become operational on schedule. The $6,800,000 request will provide the following:

...Supplemental instrumentation and facilities at the 16 Mercury stations, including the Mercury control center at the Atlantic Missile Range.

...Facilities at the U.S. Navy's Pacific Missile Range, Point Arguello, California, and its Kauai Island installation in Hawaii.

These two installations will become part of the 16-station network in place of two Air Force installations which, it now appears, must be kept free for the Defense Department's Discoverer program.

Finally, the launching pad which will undergo modification at Cape Canaveral is Pad 12, now being used by the Air Force for Atlas firings. To accommodate the Atlas-Agena B, which is scheduled for initial launchings in late spring or early summer of 1961, considerable ground support equipment must be provided. Also needed are a new umbilical tower tall enough to service the extended rocket vehicle, and a repositioning of the working platform to suit the Agena B's particular needs.

The Atlas-Agena B and the Atlas-based Centaur are vital to the Nation's space program in the coming years. The Atlas-Agena B, for example, will be capable of launching a spacecraft of several thousand pounds on a 300-mile orbit or a spacecraft of several hundred pounds on a lunar trajectory.

Members of your committee are aware, I am sure, that the House Subcommittee on Deficiencies has considered this matter and has reported favorably to the House on the entire amount of the request for this Fiscal Year 1960 supplemental appropriations.

Now, I would like to call to your attention and explain briefly the necessity for increasing by 250, NASA's Fiscal Year 1960 personnel ceiling of 9,836. We have determined that a need exists to recruit and assign promptly to the NASA Huntsville, Alabama facility an initial complement of 100 employees to accomplish the planning necessary to assure administrative support for the operation when it is finally transferred on 1 July 1960. In addition, our studies indicate an immediate need for 150 additional persons for our headquarters staff in Washington, D. C. -- an addition that would bring our headquarters strength to 683 which is the number we have established as the Fiscal Year 1961 year end complement. The proposed increase amounts to an advanced recruitment for these particular positions for reasons which I will discuss later. These increases in staff can be carried out within the Fiscal Year 1960 Salaries and Expenses Appropriation of $91,400,000, thanks to certain flexibility within that item of our 1960 appropriation.

The Special Subcommittee on Deficiencies of the Committee on Appropriations of the House of Representatives in its report dated 19 February 1960, has approved the request for 100 positions for the Huntsville facility. However, that subcommittee has approved only 75 of the 150 positions requested for the staffing of our Washington Headquarters. Gentlemen, I urge the members of your committee to restore this cut and grant our request for the full total of 150 positions.

May I point out that NASA, -- providing its budget request for Fiscal Year 1961 and the transfer of the von Braun group are approved -- will be planning, contracting for and carrying out a program in the balance of the current Fiscal Year and in Fiscal Year 1961 that will involve the commitment of $400,000,000 more in Fiscal Year 1961 than in 1960. Further, our staff will have been increased by more than 5500 employees, principally as the result of the Huntsville transfer. To plan for and manage sensibly this program of great and increasing complexity requires this modest increase in headquarters management staff.

The requirement for this immediate increase in personnel is, in my opinion, the normal and inevitable outgrowth of the expanding nature of our activities, particularly in the area of providing adequately for the development of launch vehicle systems having the thrust capabilities required to support both the short and long term projects we plan to undertake. Let me be more specific.

In late 1959 the President ordered the transfer to NASA of the Development Operations Division of the Army Ballistic Missile Agency at Redstone Arsenal, Huntsville, Alabama, along with Saturn, the 1,500,000-pound-thrust (clustered) rocket engine under development by the Division.

Subject to Congressional approval, the transfer will become effective 60 days from formal notification of the Congress on January 14 last; it will include the 4,300 scientific and technical positions from the present Development Operations Division and a provision enabling NASA to recruit up to 815 individuals from ABMA or Redstone Arsenal supporting personnel. The total supporting personnel requirement of 1,200 for Dr. Wernher von Braun's group cannot be filled entirely from the Redstone personnel because the Army requires their continued service in military programs.

The 100 persons already approved by the House Subcommittee on Deficiencies, are urgently needed at Huntsville to plan for the NASA take-over so that it goes smoothly and does not disrupt either Army or NASA programs.

The President's assignement to NASA of sole responsibility for developing high-thrust boosters, regardless of their ultimate military or nonmilitary uses, took place last year. This mission is adding heavy workloads to NASA's headquarters staff in all divisions.

Prior to that assignment, the Fiscal Year 1960 authorized strength in the Office of Space Flight Development was 113. With this added mission came the requirement for a total of 170 individuals in all phases of Space Flight Development.

In order to speed development of super boosters, therefore, we decided to split up the Office of Space Flight Development into two offices -- the Office of Space Flight Programs and the Office of Launch Vehicle Programs with the same total of 170 positions, 110 in the former and 60 in the latter.

The Huntsville group, and NASA launch operations at the Atlantic Missile Range and later, the Pacific Missile Range, will report to the Office of Launch Vehicle Programs.

Let me review briefly the divisions under the new organization. They include:

...the Office of Advanced Research Programs (formerly the Office of Aeronautical and Space Research) which is charged with advanced research in aeronautics and space. Under this office, NASA's research centers have been undergoing a major transformation in function from aeronautics and rocket research to the most advanced space research, all within existing personnel complements. There is a premium on headquarters personnel with knowledge in specific research areas; more specialists and clerical help are needed. This office would increase by 12 from 83 to 95.

...the Office of Space Flight Programs (formerly the Office of Space Flight Development) which is responsible for mission planning, payload design and development, and in-flight research and operation. As boosters get larger, payloads increase tremendously in size and complexity, adding to the pressures on scientists and engineers in the evaluation and mission-planning phase. This office would grow to 110 positions, an increase of 30.

...the Office of Launch Vehicle Programs, which I have mentioned earlier, would grow by 27 to a total of 60. Please note that the total requested for these last two offices is the same number that was planned before we decided to establish the second office.

...the Office of Business Administration, which continues with the same name and functions. It devolves upon this office to pull together into an efficient whole, NASA's variegated offices and research center operations. Additional personnel are required in systems accounting and budget analysis, and audit and procurement, for example. Again, the Huntsville transfer is an important factor in the increased personnel need. Increase in this office would be 52 for a total of 271.

I would also like to touch upon the needs of my own staff in the Office of the Administrator, an increase of 29 positions for a total of 118. The new positions are in areas including international programs, the general counsel's office, program planning, and public information.

Gentlemen, there is no gain in attempting to reduce the number of headquarters personnel requested if by that action we are left unable to discharge effectively our management function. I assert that this request was arrived at after careful study and assessment of our needs for people to support our planning, managing and evaluation functions. At this stage in our program it would be penny-wise and pound-foolish to limit our headquarters staff as the House Subcommittee has proposed.

I hope this review has been helpful to you. I respectfully urge your approval of this #23,000,000 as a supplement to our Fiscal Year 1960 appropriation. Further, I strongly urge favorable consideration of our request for advance recruitment of 100 positions for Huntsville and of my plea for restoration of the 75 positions cut by the House Subcommittee from our request of 150 positions for our Washington Headquarters staff. Your favorable action will assure more satisfactory management of this vital national program.

My associates and I will be happy to answer to the best of our ability any questions you may have.

No. 60-133

# NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

**WASHINGTON 25, D. C.**

NASA RELEASE NO. 60-134
DUdley 2-6325

HOLD FOR RELEASE UNTIL:
11:30 p.m [redacted]., Thursday,
February 25, 1960

U.S.-AUSTRALIAN AGREEMENT ESTABLISHES ADDITIONAL TRACKING STATIONS

The Department of State and the National Aeronautics and Space Administration today announced that Australia and the United States have signed an agreement which will extend the cooperative efforts of the two nations in space research. The agreement, which was signed in Canberra on February ~~25~~ 26 (2:38 Australian time), provides for the continued operation of tracking stations established during the International Geophysical Year and the establishment of tracking facilities for Project Mercury and deep space probes.

Operation of the Minitrack Station and the Baker-Nunn Camera Optical Tracking Stations at Woomera will be continued. Tracking stations at Perth and Woomera will be established for Project Mercury, the United States manned satellite program. A tracking facility also will be established at Woomera for deep space probes.

Under the terms of the agreement, the United States will provide electronic equipment; Australia will provide sites for the tracking facilities and assist in their operation and maintenance. Australian scientists will be able to use each established station for independent scientific activities when the stations are not being used for a United States program.

- END -

# NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D. C.

NASA RELEASE NO. 60-125
DUdley 2-6325

FOR RELEASE:
AFTER LAUNCH
FEB 27 1960

THIRD NASA TEST LAUNCH OF 100-FOOT SPHERE

A third sub-orbital test launch of a 100-foot inflatable sphere was conducted by the National Aeronautics and Space Administration today from its Wallops Station, Virginia, launch site.

A test vehicle carrying the sphere was launched at 6:21 p.m. EST. It boosted the sphere to an altitude of about 225 miles. It traveled about 540 miles east across the Atlantic Ocean.

The experiment was to continue test of:

- the mechanism for ejecting the sphere from its payload and inflating it in space.
- the solid propellant third stage of the Delta vehicle under development in NASA's launch vehicle program.

Similar tests were conducted from Wallops Station on October 28, 1959, and January 16, 1960. NASA plans to launch a 100-foot sphere in orbit this spring for use as a passive communications satellite in Project Echo.

Today's two-stage launch vehicle stood 32½ feet high and weighed five and one-half tons at take-off. It produced an initial thrust of 130,000 pounds.

The first stage was one Thiokol Sergeant solid rocket with two Recruit assist rockets to increase initial thrust. The second stage was an Allegany Ballistics Laboratory X-248 solid rocket which will be the third stage of the Delta vehicle.

The 100-foot sphere was made of mylar plastic half a mil thick (half of one thousandth of an inch) coated with vapor deposited aluminum. It weighted about 130 pounds. The aluminum provided a high degree of reflectivity of light and radio signals.

During the January 16th experiment, a 960 megacycle radio signal from Bell Telephone Laboratories, Holmdel, N. J., was bounced off the sphere and received at a General Electric station at Schenectady, N. Y., and a Massachusetts Institute of Technology station at Round Hill, Mass.

At launch today, the sphere was folded into a round magnesium container $26\frac{1}{2}$ inches in diameter. The complete payload package weighed about 190 pounds.

After ejection from the container, inflation of the sphere was begun by residual air inside it. Further inflation was accomplished by 30 pounds of sublimating powders carried in the sphere.

The payload did not carry a beacon transmitter for tracking but a telemetry transmitter on the second stage reported vehicle performance to ground stations at Wallops.

The 100-foot sphere was conceived by Langley's Space Vehicle Group headed by William J. O'Sullivan, Jr. The sphere and vehicle were developed by Langley's Applied Materials and Physics Division, Joseph A. Shortal, Chief. Project engineer was Norman L. Crabill

of AMPD. Leonard Jaffe of NASA Headquarters is chief of commu-
ications satellite programs.

- END -

STATEMENT OF DR. MORRIS TEPPER

CHIEF, METEOROLOGICAL SATELLITE PROGRAM, NASA

Before

HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS

## The NASA Satellite Applications Program

Gentlemen: After having heard the presentations so far, you may be wondering somewhat whether the exploration of space does not have a more practical side, something closer to our activities as individuals. This is indeed the case, as I expect to show during the next half hour, as I present the NASA Satellite Applications Program--a program involving satellites that will have an impact on the day-to-day living of all of us.

Last year, we presented the general aspects of the program on which we had embarked.

Today, I would like to acquaint you with our progress during the past year, our activity of the present and our plans for the immediate future.

The three primary fields of satellite applications to which I shall refer are--the meteorological, the communications, and the navigation satellites.

The first chart states very briefly our objectives in these fields. They are:

Meteorological: To develop a satellite capability for providing world-wide meteorological information.

Communications: To develop a satellite capability for making possible world-wide communications.

Navigation: To develop a satellite capability for making possible all-weather navigation at low cost.

I shall now discuss each of these programs in turn.

## Meteorological Satellite

Our meteorological satellite program has been designed to acquire certain information needed by meteorologists in order to adequately describe and understand atmospheric processes and to predict the weather. This information includes:

a. Cloud observations, both day and night, on a global basis.

b. The heat budget of the earth and atmosphere.

c. Indirect measurements of the temperature structure and composition of the atmosphere.

d. Radar coverage, giving world-wide precipitation information.

The next chart (CHART 2) shows the kinds of instruments being considered for inclusion on-board satellites which will provide this information.

a. Photocells and television - storm location, cloud cover, cloud type and cloud motion.

b. Scanning infrared radiation detectors - average temperature of the earth's surface and lower atmosphere, temperature of cloud tops.

c. Non-scanning infrared radiation detectors - gross heat budget measurements i.e. reflected solar radiation and radiation from earth and atmosphere.

d. Spectrometer - composition of atmosphere, water vapor, ozone, carbon dioxide, and stratospheric temperatures.

e. Radar - rain and snow areas, heights and intensity of their layers.

The next chart (CHART 3) shows the rate with which we are accomplishing our program.

During the past year, we had two successful launches of satellites containing major meteorological instrumentation.

Vanguard II contained a scanning photocell for mapping areas of high reflectivity (essentially cloud cover). As has already been explained, a wobble developed upon launch and we are experiencing some difficulty in reducing the data.

Explorer VII, which is still providing useful data, contains, among its other scientific instrumentation, a non-scanning IR radiation detector system for heat budget measurements.

Currently, we are actively preparing for the launch this calendar year of TIROS I and II. TIROS I contains two television camera systems for cloud cover photography and TIROS II, the later version, will have in addition both scanning and non-scanning infrared radiation detector systems.

Our future program, the series of satellites designated Nimbus, will contain improved instrumentation growing out of our experience with previous satellites. Hopefully, later versions of Nimbus will carry new instrumentation such as a spectrometer or a radar on-board.

On the next chart (CHART 4), we have an artist's drawing of the TIROS satellite. The following are its characteristics:

1. Launch vehicle - Thor-Able II (TIROS I), Thor-Delta (TIROS II);
2. Stabilization - Spin stabilized;
3. Weight - 270 pounds;
4. Size - 42-inch diameter, 19 inches high;
5. Orbit - 380 nautical miles, circular;
6. Inclination - About 50° to equator;
7. Lifetime - 90 days;

8. Instrumentation - Two television systems, scanning and non-scanning IR and associated electronics;
9. Power - Solar cells and storage batteries;
10. Launch - From AMR;
11. Tracking - Minitrack and Millstone Radar;
12. Data acquisition - U. S. Army Signal Corps Station at Fort Monmouth, USAF station at Kaena Point, Hawaii.

Participation in TIROS has been extensive (CHART 5). TIROS was initially begun in the DOD. On April 13, 1959, over-all project direction and coordination was transferred to NASA.

U. S. Army (USASDRL and contractors from industry - primarily R.C.A.): Development of payload and selected ground equipment, data acquisition and data transmission.

U. S. Air Force (BMD and contractors from industry - STL, Douglas and Lockheed): Development of launch vehicle, mating of vehicle and payload, launch, data acquisition. AFCRC will assist with data analysis and interpretation.

U. S. Navy (NPIC): Will assist in the photo analysis.

U. S. Weather Bureau: Data analysis and interpretation, data dissemination and historical storage.

In addition, NASA has organized the Joint Meteorological Satellite Advisory Committee (JMSAC) with membership from ARPA, Army, Navy, Air Force, Weather Bureau, and NASA with the following objectives:

a. To consider the requirements of the DOD and NASA in the Meteorological Satellite Program;
b. To serve as a medium of interchange of information among NASA and DOD members;
c. To assist wherever possible and appropriate in operating programs.

It is our intent that through the coordination of requirements in this Committee we shall be able to develop a true national meteorological satellite program, responsive to the needs of both the military and civilian users.

Meteorological satellite data, particularly the photographs of cloud cover, will present a new kind of data previously unavailable, to the meteorologists. In order to develop techniques of analysis and photo interpretation by means of which it will be possible to extract significant meteorological information from such photographs, meteorologists are carefully studying all available photographs taken from high altitudes.

For example during the past year, there have been several instances where a camera containing film was placed in a recoverable nose cone of an Atlas or Thor launch vehicle. Although the initial and primary purpose for the camera was non-meteorological, it turned out that some very good pictures of the earth's cloud cover emerged as a by-product. On the next chart (CHART 6) in the upper left-hand corner is a mosaic of several photographs taken at about 300 nautical miles elevation during the flight. The clouds were transcribed onto a map and are shown in tinted blue on the accompanying map. Superimposed on the chart is the weather situation for the day. We see how remarkable is the correspondence between the major cloud areas and the major weather storm regions - as shown by the stationary front, the equatorial trough and the easterly wave.

This very preliminary analysis was performed by the scientists of the General Electric Company--the company directly concerned with the nose cone experiments. However, as you can see, there is a considerable amount of additional detail on this photograph. The Weather Bureau is studying these details in terms of meteorological significance.

The Weather Bureau is also conducting similar kinds of studies, though necessarily more theoretical in nature, in the field of radiation, data handling, data processing, and operational utilization of satellite data in order to be better prepared to interpret and use the data when they are available.

So much for TIROS and preparing for its data. What is beyond TIROS?

In order to understand better the direction which we are following in the follow-on to TIROS--it is important to understand two of the basic limitations of TIROS. The next chart

(CHART 7) illustrates these weaknesses. TIROS will be launched in an inclined orbit and will be space oriented. The former means that TIROS will reach a maximum northern and southern latitude (about 50°). It will view events primarily between these latitudes so that poleward from these latitudes we shall have little or no data from this satellite. Secondly, by being space oriented TIROS views the earth only part of the time during its orbit. The rest of the time it looks glancingly at the earth or out into space. Our follow-on satellite, Nimbus, will correct this. It will be in a polar orbit and so will cover all latitudes from pole to pole; it will always face the earth.

The other characteristics of Nimbus are (CHART 8)

1. Launch vehicle - Thor AGENA B;
2. Stabilization - earth oriented, pneumatic and inertia wheel technique;
3. Weight - 650 pounds;
4. Orbit - 600 nautical miles, circular;
5. Inclination - polar orbit;
6. Lifetime - six months;
7. Instrumentation - advanced TV, scanning and non-scanning IR, spectrometer and radar on later versions;

8. Power - solar cell and storage batteries;
9. Launch - from PMR.

Maximum data acquisition from a satellite in a polar orbit would be from a station located at the pole or as close to it as feasible. Thus, we are looking into the possibility of establishing a station in high latitudes at which the Nimbus data might be acquired.

## Communications Satellites

To refresh your memory: Satellites which can be used to provide communications over large areas of the earth can be placed into two broad categories--the active repeater satellites and the passive satellites. The active repeater satellites contain electronics and an appropriate power source which permit a radio signal, sent from one point on the earth, to be received on-board the satellite, amplified, and then to be retransmitted to a distant receiver. The other category, the passive satellite, is comprised of satellites which merely reflect back toward the earth radio signals originating on the earth.

Because of some rather immediate tactical needs, the DOD has embarked on a program to develop certain forms of the active repeater communications satellite. NASA, as was implied earlier in the introduction, is interested in establishing the technology necessary to the design of the more general communications satellites for civilian and commercial use. In the area of active repeater communications satellites, NASA is watching with interest and relying on the DOD programs to provide the early stages of development. NASA has established a research and development program in the area of passive communications satellites.

Our initial effort calls for the development of large spherical satellites and the investigation of this form of satellite as a communications medium. This program has been named Project Echo.

(CHART 9)

A 100-foot diameter inflatable spherical satellite, developed by our Langley Research Center will be placed in a circular orbit about the earth at an altitude of approximately 900 nautical miles. The satellite is made of mylar, one-half thousandth of an inch thick, with a vapor-deposited coating of aluminum to provide reflectivity. It weight approximately 136 pounds and has 31,416 square feet of surface area. The satellite is evacuated and folded into a 26-inch diameter container such as this (model). Here, we see a folded sphere in a transparent container as it appears prior to launching (model). These mylar spheres were fabricated under contract by General Mills Company and Schjeldahl Company. This entire package will be placed in orbit using a Delta vehicle, and then the container will be opened to release the sphere. Approximately 20 pounds of a sublimating powder, placed inside the sphere, will cause the satellite to inflate in the vacuum of space.

To investigate the characteristics of this satellite as a communications medium and to determine the condition of the sphere in orbit, Project Echo calls for a series of communications experiments between JPL, Goldstone, California and BTL, Holmdel, New Jersey. Signals originating at Goldstone will be reflected by the satellite and received at Hclmdel. Signals from Holmdel to Goldstone via the satellite will make use of a different frequency. These communications facilities are now under construction.

The satellite has undergone considerable ground testing; but the real test is to inflate the payload in space, for we do not have vacuum facilities large enough to inflate this structure on the ground as part of this development. The Langley Research Center has programmed several ballistic launches of the 100-foot diameter sphere from Wallops Island. Two such tests have been performed: the first on October 28, 1959 and the second on January 16 of this year. We have prepared a short film showing the preparation for and the launching of the first of the two tests mentioned. I should like to show this film now.

(FILM)

This first scene shows the 100-foot diameter sphere inflated in a large hangar at Weeksville, North Carolina, to determine the quality of construction.

Here, we see the folding table. The sphere is first folded into a long thin shape, 153 feet long with over 400 accordian-type pleats.

Here, we see the payload container.

The sphere is then carefully folded into one-half of the container.

The other half of the container is put in place.

Here, we see being assembled the telemetry equipment which will radio back events during the flight.

Next, we shall see the second stage rocket. This, incidently, is the same rocket we shall use to finally eject the payload into orbit on the Delta vehicle; thus, we are testing as nearly as possible the final configuration for the orbital experiment.

The payload is now being fitted onto the second stage rocket of the launching vehicle.

Here, the ballistic launching vehicle is being assembled at Wallops Island. The first stage is a Sergeant rocket.

The second stage and the payload are now being added.

A protective nose cone has been added which will be jettisoned after the vehicle leaves most of the atmosphere.

The test was made just after sunset so that the sphere would be visible by reflected sunlight against a dark sky.

The rocket is fired. The vehicle is spinning to provide stability.

The sphere is ejected and inflated at an altitude of approximately 80 miles.

(END OF FILM)

This first test showed a fault in the payload, for the sphere ruptured on inflation. The second test suffered from a vehicle fault. However, the sphere was ejected and the data (which is still being analyzed) indicate that the payload fault observed in the first test may have been successfully corrected.

(CHART 10)

Rather large ground facilities are required for the communications experiment and here we see one of two 85-foot diameter antennas which will be employed in Project Echo.

(CHART 11)

A specially designed antenna is under construction for the experiment at Bell Telephone Laboratories in Holmdel. This antenna is designed to eliminate noises which are a result of the surroundings. The use of such techniques will permit the detection of extremely small signals.

(CHART 12)

The participants in Project Echo are shown here. NASA is providing the management and the payload development, tracking, etc. Jet Propulsion Laboratory, West Coast communications site and Bell Telephone Laboratories, the East Coast communications site. Industry is providing many of the components; the mylar spheres, radio beacons, antennas, transmitters, etc.

Last, but by no means least, are the independent experimenters. We have indicated that the military services will perform their own experiments but many other organizations will take advantage of the existence of this satellite and will perform additional radio propagation experiments. NASA is cooperating with these experimenters and their effort, in turn, will augment the sum total of extremely valuable information to be gained from Project Echo.

NASA plans three launches of the 100-foot diameter sphere (the first, an inclined orbit and the last two, polar orbits) to determine the usefulness of such spheres as communications satellites and to determine the technology required to place and sustain such large structures in the space environment.

A single satellite of this type cannot comprise a satellite communications system, for as shown here--

(CHART 13)

Even though with a single satellite, communications can be established between any two stations within a rather large area, as the satellite moves relative to the earth its area of coverage moves with it. If continuous communication is to be maintained a number of satellites will have to be in orbit so that at least one is always in sight of the two stations desiring to communicate. It would take on the order of 26 spheres in a 3-4000 mile orbit to provide 99% availability, if the spheres were randomly spaced. Because of this requirement and the advent of larger boosters in the coming years, the follow-on program to Project Echo calls for the development of the ability to place a number of spherical satellites in orbit with a single booster vehicle.

Feasibility studies of larger structures and other, perhaps more efficient, reflectors will continue but the experience and technology to be gained in Project Echo will provide an invaluable foundation on which to build the required technology.

## Navigation Satellite

At the present, NASA does not have an active development program in navigation satellites. As you know, a navigation satellite system is being developed by the DOD. We are keeping in close touch with these developments so as to be in a position to evaluate the usefulness of the system for civilian application.

The total funds required to carry out the Satellite

Applications Program as I have presented it are $26,300,000 of this $20,700,000 is for the meteorological satellite program and $5,600,000 for the communications satellite program.

- END -

MT:jh
1-29-60